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World List abbreviation: *E. Afr. agric. for. J.*

VO . XXVII — NO. 1

JULY, 1961

PERIODICAL

: Sh. 4

(*scription Sh.* 15)
(*D.M.*: 10.19)
(*llars*: $2.41)

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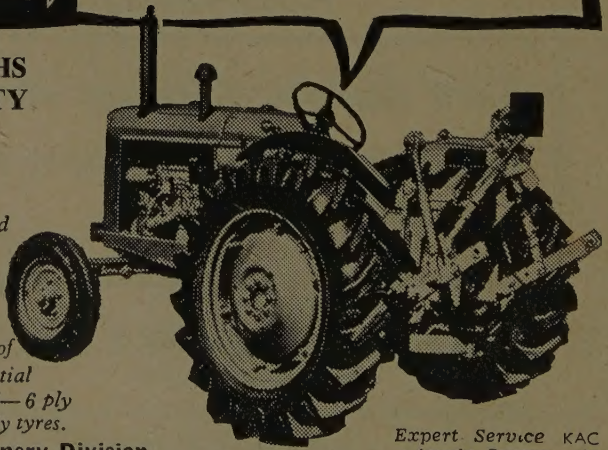

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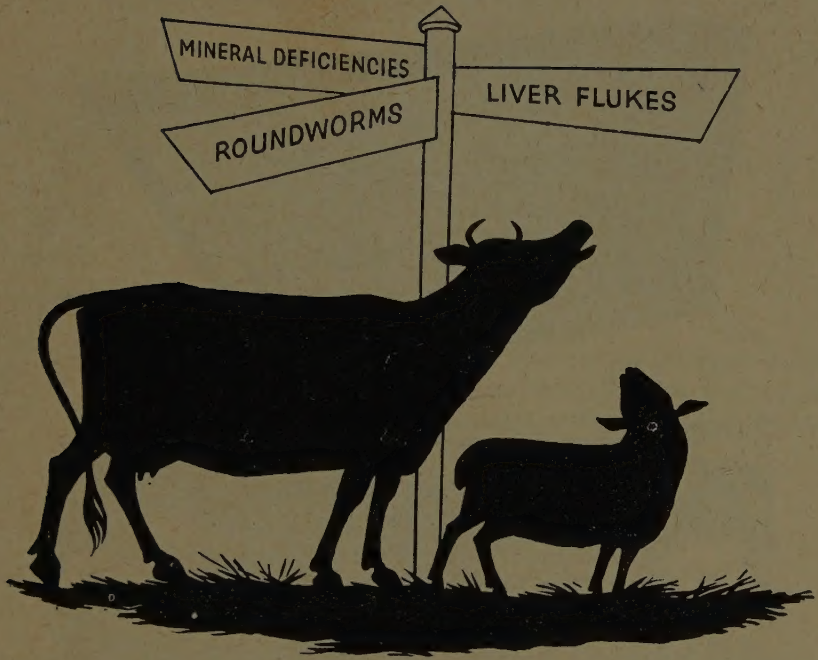

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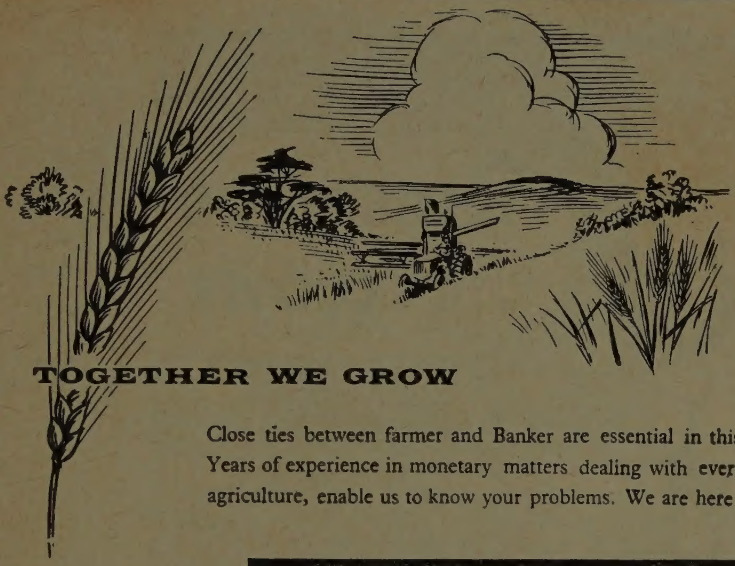

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Vol. XXVII—No. 1 **JULY, 1961**

Printed and published by the Government Printer, Nairobi

Issued under the authority of the East Africa High Commission and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue)

Editorial Board: Director of E.A. Agriculture and Forestry Research Organization; Director of E.A. Veterinary Research Organization; Directors of Agriculture, Kenya, Uganda and Zanzibar, and Commissioner for Agriculture, Tanganyika; Director of Veterinary Services, Kenya and Uganda, and Commissioner of Veterinary Services, Tanganyika; Conservators of Forests, Kenya, Tanganyika and Uganda.

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EAST AFRICAN AGRICULTURAL AND FORESTRY JOURNAL

MINERAL NUTRITION OF COFFEE. PRELIMINARY RESULTS WITH THE LEAF ANALYSIS TECHNIQUE

By J. B. D. Robinson, Coffee Services, Department of Agriculture, Kenya*

(*Received for publication on 10th March, 1961*)

In recent years many investigations have been carried out in *Coffea arabica* with the leaf analysis technique. Machada (1956, 1958) in Colombia, Medcalf *et al* (1955) and Lott *et al* (1956), in Brazil, have related fertilizer application and crop responses to leaf analysis values; Culot and Van Wambeke (1958) studied mineral deficiencies in the Kivu area of the Congo Republic and defined the normal range of adequacy and the upper deficiency threshold levels for a number of macro and micronutrients. Muller (1960) has studied the question of the age of the leaf sample in relation to the nutritional status of the coffee tree and has described the nutritional gradient along cropping and non-cropping branches for some of the macro-nutrients. He has emphasized the value of the technique of "differential analysis" on bearing trees when investigating the macronutrients which are limiting to crop production.

In East Africa the leaf analysis technique has been used for a number of years but often in a rather haphazard way, in that insufficient importance has been attached to the age of the leaf sample taken, the condition of the tree, the availability of soil moisture, cropping level, cultural treatments prior to sampling, etc. One example of the value of the differential leaf analysis technique has been demonstrated for East African conditions, in Kenya and Uganda, where it was used to determine and define a condition of magnesium unbalance in arabica and robusta (Coffea canephora) coffees, Robinson and Chenery (1958).

In 1956 work was commenced at the Coffee Research Station, Ruiru, on several aspects of leaf analysis in arabica coffee. Some results of this work are reported here. The coffee studied was all grown on the Kikuyu red loam coffee soil type. Numerous chemical analyses have been reported by Robinson (1959/60); typical analytical values from the coffee area where the results reported here were obtained are pH=5.7, K=1.8 m.e. %, Ca=4.4 m.e. %, Mg=2.5 m.e. %, P=17 ppm (Mehlich *et al*, unpublished methods of analysis). The physical characteristics of this soil have been described by Pereira (1955, 1957).

Unless otherwise stated analytical values refer to cropping primary branches of mature, unshaded coffee pruned to the multiple stem, i.e. three stem, system. At least 40, and more frequently 60 leaves are taken per sample; in practice the larger number may be reduced slightly where the same trees are sampled at regular intervals throughout a season, e.g. in the study of seasonal trends.

Age of the Leaf Sample

The importance of the age of sample collected to define the status of a particular plant nutrient or the relationship between several nutrients in the leaf is well illustrated by the data in Table 1. It is known that the collection of the first open or even the fourth mature leaf pairs on a bearing primary, usually the nonbearing portion of the primary, i.e. the current season's growth, will not always serve to define a potassium/magnesium unbalance, Robinson and Chenery (1958). It is necessary to sample older leaves with coffee cherry present in the leaf axils.

The coffee leaves which were sampled to provide the data in Table I were collected from trees in a monoclonal block of the Kenya selection, SL 28. The comparison is between heavily bearing and very lightly bearing trees. The coffee was mulched with Napier grass (*Pennisetum purpureum* K. Schum) and irrigated, although these samples were collected during the long rains, 1956, when there was ample available moisture in the soil.

Less than 0.2 per cent magnesium in leaf dry matter and/or a ratio of K: Mg greater than 10:1 has been defined as the criterion of magnesium unbalance, Robinson and Chenery (1958). The heavy bearing coffee is deficient in

---

* Present address: Coffee Research Station, Lyamungu, Moshi, Tanganyika.

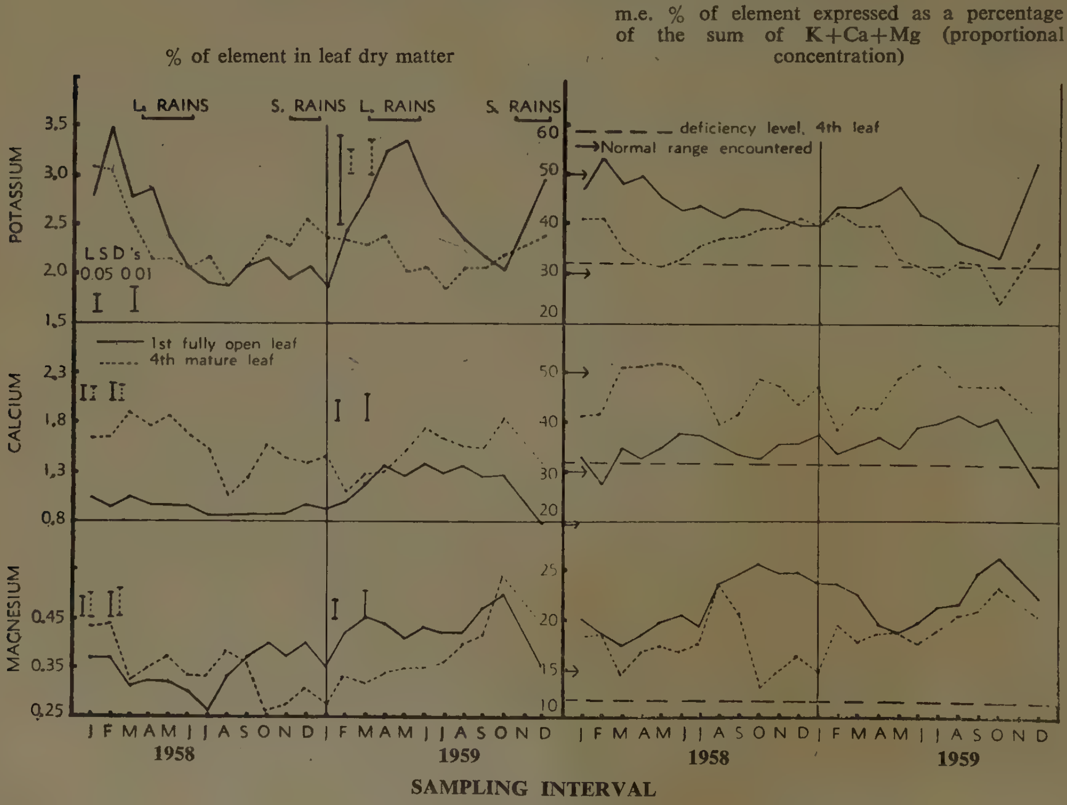
TABLE I.—COMPARATIVE ANALYSIS OF LEAF SAMPLES FROM BEARING AND NON-BEARING COFFEE, POTASSIUM AND MAGNESIUM

Sample	Node Number	Potassium % (in leaf dry matter)	Magnesium % (in leaf dry matter)	K : Mg Ratio
(*a*) Heavy bearing coffee—				
1956, non-bearing wood ..	1—5	2·12	0·41	5·1 : 1
	6—10	2·35	0·25	9·4 : 1
1955, bearing wood.. ..	11—16	3·10	0·07	44·3 : 1
	17—21	3·98	0·13	30·6 : 1
(*b*) Light bearing coffee—				
1956, non-bearing wood ..	1—4	2·35	0·41	5·7 : 1
	5—7	2·90	0·37	7·9 : 1
1955, bearing wood.. ..	8—12	2·87	0·31	9·2 : 1
	13—17	2·75	0·31	8·8 : 1

magnesium and unbalanced in relation to potassium whereas the light bearing coffee is not. The sampling and analysis of the young pairs of leaves in this instance would not have revealed this condition; similar results to this have been obtained with nitrogen and phosphorus. In the presence of heavy crop, nitrogen, phosphorus, potassium and magnesium are usually withdrawn first from the older leaves and particularly from those with cherry in the axils.

A comparison was made over a two-year period, January, 1958, to December, 1959, between the potassium, calcium and magnesium contents of the first fully open and the fourth mature leaf pairs. The results are summarized

Fig. I.—Comparative analysis of the 1st fully open and 4th mature coffee leaves



in Figure I where they are expressed as percentage by weight in the leaf dry matter and, after conversion of the percentage data into combining equivalents (concentrations), each element is expressed proportionally as a percentage of the sum of K + Ca + Mg.

The weight percentage potassium content of the two leaf samples of different ages varies at different sampling times: fluctuations are less extreme in the fourth mature leaves particularly during 1959. However, there is no very consistent relationship apparent over the whole period. When the same results are expressed as proportional concentration it is apparent that for a large part of the sampling period there was an appreciably smaller proportion of potassium present in the older leaf samples.

The calcium curves differ from the potassium curves in the same samples; the older leaves contain substantially more calcium over the entire period and the values fluctuate less widely in the younger samples. Whilst this is apparent from the weight percentage curves it is much more clearly apparent in the proportional concentration curves.

The magnesium figures are also different for the two leaf ages and when expressed as a weight percentage, it is apparent that the younger leaf, as for potassium, can contain either less or more magnesium than the older leaf. However, as with potassium, when the results are expressed as proportional concentration, the older leaves contain a lower proportion of magnesium than do the young leaves. Of greater interest is the way in which the data clearly illustrates the reciprocal concentration relationship between potassium and magnesium in the leaf. Although the seasonal trends of the potassium and magnesium curves are not the same for the two leaf ages (collected from the same trees) this reciprocal relationship is apparent in both the samples.

Applying the limiting levels of Culot and Van Wambeke (1958), for potassium, calcium and magnesium, to the proportional concentration data (coarse dotted lines in Figure I referring to the fourth mature leaf sample only) it is apparent that by their standards the proportion of calcium in the cation sum is high, the proportion of magnesium is adequate throughout the sampling period, whereas the proportion of potassium closely borders the deficiency level in the year of a good crop (1958, 7.9 cwt. clean coffee per acre) and is deficient in a year of heavy crop (1959, 15.3 cwt. clean coffee per acre) during the latter stages of crop maturation, i.e. June to October. However, it is know that this soil is not deficient in available potassium and indeed leaf potassium values when expressed as a percentage in dry matter, are quite adequate when compared with established deficiency values, i.e. less than 1.5 per cent K in leaf dry matter is considered low; less than 1 per cent K in leaf dry matter is considered to be deficient, Culot and Van Wambeke (1958), Lott *et al* (1956), Robinson (unpublished results). The low potassium values are in this case attributed to dry soil conditions which prevented uptake of potassium at a time of high demand in the tree, i.e. during crop maturation. Adequate irrigation during this period would probably have prevented this relationship developing to a critical stage.

Thus leaf potassium and magnesium values on a weight percentage basis, differed but not consistently, whereas the calcium figures showed a consistent difference over the full sampling period. Expressed on a proportional concentration basis older leaves contained less potassium and magnesium but more calcium, than did younger leaves.

Further aspects of the method of expressing the data are discussed in a later section of this paper.

Position of the Leaf Samples

The importance of the position on the tree from which leaf samples are collected, i.e. the side of the tree or the height above ground level, may be illustrated by the results obtained in a study of the influence of mulch position on some aspects of the mineral nutrition of coffee. Organic mulches, e.g. Napier grass, are frequently applied in the alternate or every inter-row space in Kenya. This leads to a one-sided fertility effect in the soil which can be assessed comparatively by soil analysis, Robinson (1956/57).

It is known that the translocation of plant foods from the roots to the branches of arabica coffee follows a spiral course and that therefore plant foods from the soil on one side of the three do not travel only to branches on the same side of the tree. Leaf samples (fourth leaf pair) were collected in equal numbers from four opposite sides of the coffee trees, north, south, east and west and from the lower half (heavy crop) and the upper half (much less crop) of the trees. Three field treatments and two absolute field replications were sampled in this investigation and the leaves were analysed for potassium, calcium and magnesium. The results are summarized in Table II.

Table II.—The Influence of Leaf Position on the Tree and its Chemical Composition

(*a*) The side of the tree:

Element	North	South	East	West
Potassium (K)	2·44	2·33	2·49	2·29
Calcium (Ca)	0·87	0·90	0·92	0·93
Magnesium (Mg)	0·21	0·21	0·23	0·20

(*b*) The elevation in the tree:

Element	Upper half	Lower half
Potassium (K)	2·35	2·43
Calcium (Ca)	0·74	1·07
Magnesium (Mg)	0·19	0·24

Notes—

1. Figures in II(*a*) are means of 12 sample analyses; figures II(*b*) are means of 24 sample analyses.
2. Least Significant Differences: II(*a*), 2 means of 12: K = 0·14*; 0·19†; Ca and Mg figures were not significantly different (N.S.) II(*b*), 2 means of 24: K = NS; Ca = 0·11‡; Mg = 0·04‡.
3. *, †, ‡, = significant difference at P = 0·05, 0·01 and 0·001 respectively.

In this experiment the side of the tree from which the sample was taken influenced significantly the level of potassium found but not the levels of either calcium of magnesium. The west side of the tree receives the greatest intensity of direct sunlight in east of the Rift Valley areas of Kenya, and these leaves contained significantly less potassium than those from the east side of the tree which receives the least. This difference was found not to be related to any of the three field treatments sampled, i.e. the presence or absence of mulch on the north or the south sides of the tree. It is attributed to a solar radiation intensity effect.

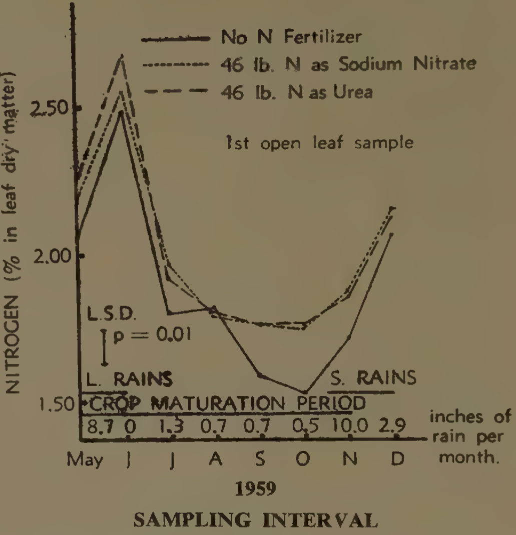
Leaves collected from the upper half of the tree contained very significantly more calcium and magnesium than those from the lower half; the difference between the potassium values was not significant although there was a similar trend. The most obvious difference between the upper and the lower half of the tree in this experiment was the quantity of crop present which was very much greater on the lower half since the trees were in the early stages of new multiple stem cycle at the time of sampling.

It should be noted in passing that in all cases the trees were suffering from an unbalance of potassium and magnesium.

Seasonal Variation in Leaf Composition and the Method of Expressing Analytical Results

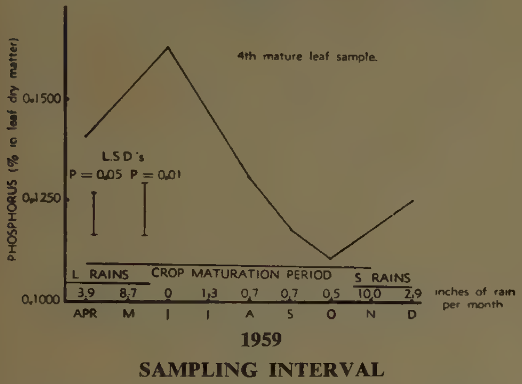
Nitrogen.—There is a marked seasonal variation in leaf nitrogen levels (first fully open leaf pair) which can be related to weather conditions (including soil moisture availability) and the crop maturation period in bearing coffee. Variations are substantial and require that the interpretation of results must be related to the time of sampling as well as the age of the leaf sample collected. An example of the type of variation found is given in Figure II. The coffee was not mulched.

Fig. II.—Seasonal variation of nitrogen in the coffee leaf



Values reached a peak towards the end of the long rains (late March-early June); earlier in the rains when growth was rapid, Wormer (1959/60), values were lower. During the dry months, late June to October/November when the short rains occur, there was a steady and significant decrease of the leaf nitrogen content. This is attributable to removal from the leaf to the crop at a time when dry topsoil conditions severely limit the uptake of available nitrate. It is not necessarily the result of a lack of available nitrate in the topsoil at this time, Robinson (1960). A short wet spell at the end of July (1¼ in. rain) probably accounted for the similarity of the July and August values. Crop maturation and harvesting took place in the latter months of the sampling periods; with the onset of the short rains (intermittent rainfall and sunny periods) the last of the crop matured quickly and was harvested, available soil moisture was present, some vegetative growth took place and leaf nitrogen values rose. Whilst the exact timing of these changes may vary from year to year with the actual timing of the rain seasons and with unseasonal showers, the other factor which influences leaf nitrogen values significantly is the crop. A non-cropping or very lightly cropping tree (in a particular coffee area) does not exhibit such a marked decrease in leaf nitrogen in the period between the long and the short rains. This is particularly the case in the older leaves on the primary.

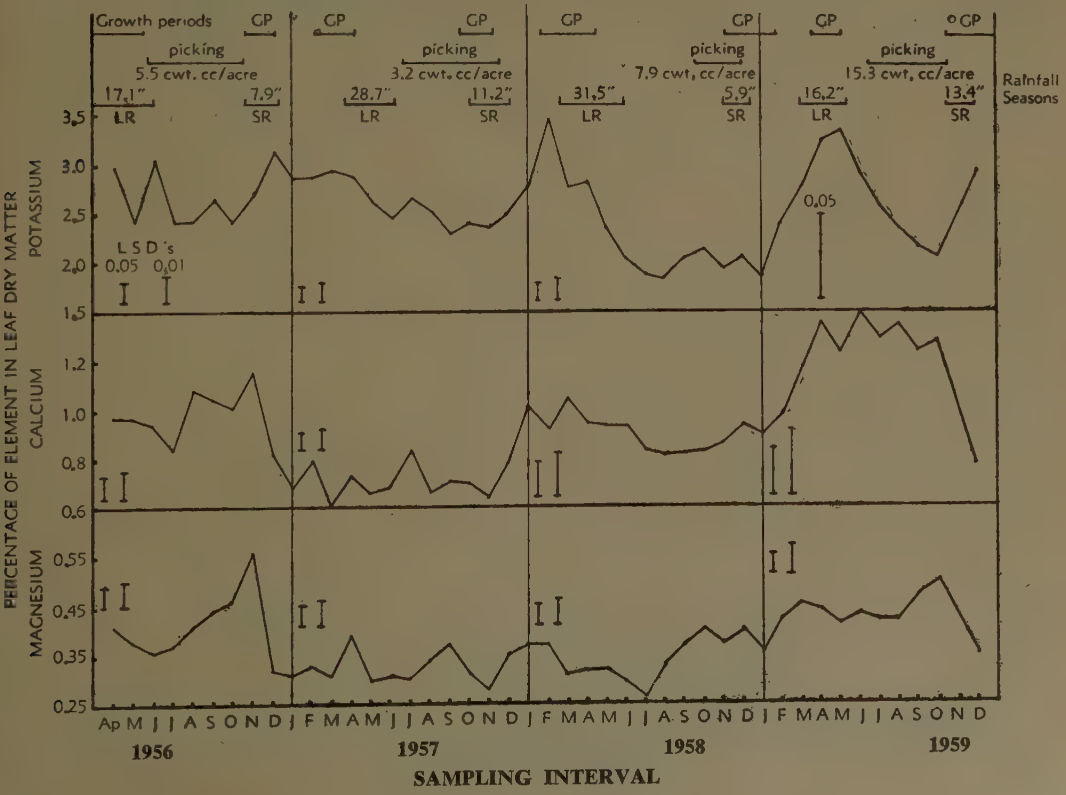
Fig. III.—Seasonal variation of phosphorus in the coffee leaf



Phosphorus.—Leaf phosphorus values followed a similar trend to nitrogen in cropping coffee on this station. The curve in Figure III, fourth mature leaf sample from mature, bearing, single stem coffee, summarizes the results of an irregular series of samples taken during 1959. (Refer also to Figure VI.)

Potassium, Calcium and Magnesium.—Between April, 1956, and December, 1959, regular monthly leaf samples (first fully open leaf) were collected and analysed for their potassium, calcium and magnesium contents. This coffee completed a cycle on multiple stem in December, 1957, when the old heads were removed. During 1957 there was a small crop on the old heads as well as the developing new heads (three suckers were allowed to grow up in

Fig. IV.—Seasonal variation of potassium, calcium and magnesium in the 1st fully open coffee leaf



November, 1956). After January, 1958, leaf samples were collected from the new heads. The crop was good in 1958 and heavy in 1959. The results of leaf analyses are shown in Figure IV together with an indication of the rainfall, vegetative growth and cropping periods.

The variation in potassium levels (% in leaf dry matter) in the leaf appears to follow closely crop maturation and harvest periods. At the time of flowering and during the early stages of crop maturation until the end of the long rains, values were high. Following the long rains and as the crop matured and was harvested leaf potassium values decreased rapidly; after the crop was off the levels began to increase, particularly where the crop was removed before or early in the short rains. The difference between the highest and the lowest leaf values in the last two years when good crops were harvested was substantial.

Calcium values show a tendency to remain high or even to increase when potassium values decrease. The most marked exception to this occurred in 1957 when, besides a small crop, three new multiple stem heads were growing up rapidly. Presumably a large part of the calcium absorbed by the roots went into the vegetative growth of these new heads.

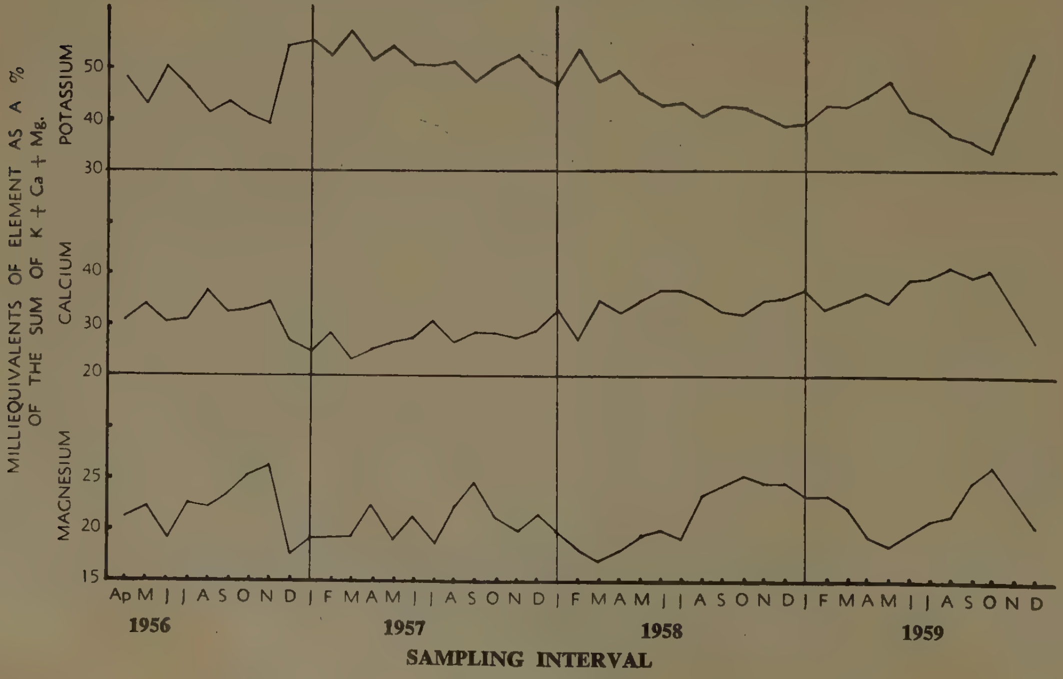
Whilst leaf potassium values tend to increase at the time of the onset of the rain seasons, leaf calcium values almost invariably show a decrease.

Magnesium values followed quite closely the calcium changes in the leaf with time although the range of fluctuation is smaller.

When each of these elements is expressed as a proportional concentration of the sum of the K + Ca + Mg cations calculated in milli-equivalents per 100 gms. dry matter in the leaf, the large potassium and calcium fluctuations disappear.

A comparison of the potassium and calcium curves in Figure V reveals a reciprocal relationship in the coffee between these two ions. From 1957 to the end of 1959 the proportional concentration of potassium decreased whilst that of calcium increased. During this period, and particularly on the new multiple stem heads during 1958 and 1959, vegetative growth decreased whilst crop production increased substantially. Increased crop production lowered the levels of leaf potassium; reduced growth, i.e. greater leaf age at sampling, resulted in higher leaf calcium levels and by deduction, lower leaf potassium values *(see*

Fig. V—Potassium, calcium and magnesium content of the 1st fully open coffee leaf expressed as a percentage of the sum of K+Ca+Mg (proportional concentration)



previous section for comparison of potassium content in different ages of leaf). This is considered to be a reasonable explanation of these trends.

Leaf magnesium concentrations varied during the same period and there is a regular rhythm apparent in the curves. With the decrease in growth rate following the long rains, i.e. the May-July period, the proportion of magnesium in the leaf increased until active growth was resumed with the onset of the short rains in October-December period.

Some Effects of Mulch and Fertilizer on Leaf Composition

Napier Grass Mulch.—Leaf samples (fourth mature leaf pair) were collected at monthly intervals from April through December, 1959. The control, unmulched and the alternate inter-row Napier grass mulch plots were sampled comparatively in the Mulch and Soil Regeneration trial. The mulch treatment had been applied for ten years prior to sampling and the crop yields in the 1959 season were, no mulch = 11.58 cwt. per acre clean coffee, alternate inter-row mulch=15.68 cwt. per acre clean coffee. Comparative soil samples (0—4 in.) were also collected from these two treatments. The soil analysis data and the mean leaf analysis values for the entire sampling period, are summarized in Table III.

Table III.—The Influence of Napier Grass Mulch on Soil and Leaf Analyses

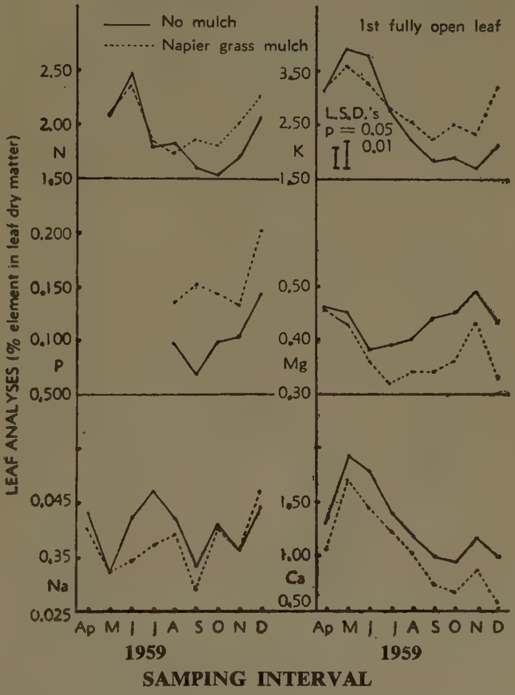
Treatment	Element					
	N	P	Na	K	Ca	Mg
Coffee Leaf:						
No Mulch	1·972	0·1086	0·044	2·56	1·29	0·44
Mulch ..	2·014	0·1568	0·039	2·72	1·09	0·38
Coffee Soil:						
No Mulch	50*	15	—	1·5	7·0	3·8
Mulch ..	26*	40	—	3·1	7·8	5·7
L.S.D.'s for leaf analysis data ..	NS	0·0343^{xxx}	0·008^{x}	0·15^{x}	0·14^{x}	0·05^{x}

Notes—

1. *Biological analysis with Cunninghammella Blakes—leeana fungus test, after Mehlich.
2. Coffee leaf figures as percentage in leaf dry matter. Coffee soil figures as: N = growth percentage of—N treatment; P = parts per million in air dry soil; K, Ca and Mg = milli-equivalents per 100 gms. air dry soil.

The annual application of Napier grass over a period of ten years has had very significant effects on the mean nutrient levels in the fourth mature leaf sample collected from April through December. Despite the higher cropping level, the leaves from the mulched coffee contained more nitrogen, significantly more phosphorus, sodium and potassium and significantly less calcium and magnesium. Growth rate as well as crop level, soil moisture and increased soil fertility will have influenced the calcium and magnesium values in particular. Comparison of the seasonal changes in leaf nutrient levels for the two treatments are summarized in Figure VI.

Fig. VI.—A comparison of changes in leaf composition for coffee ± a grass mulch

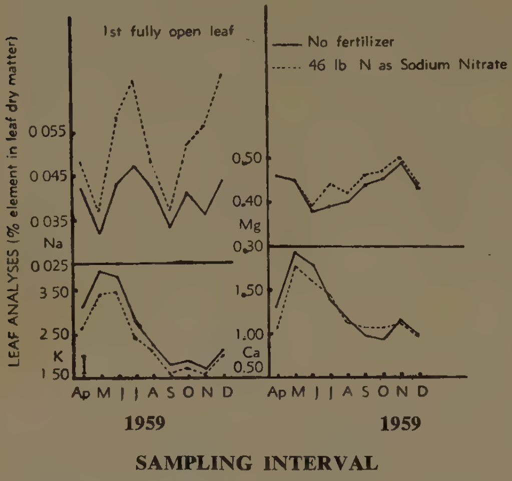


During the latter stages of crop maturation nitrogen and potassium levels were higher in the mulched coffee leaf samples; phosphorus values were consistently higher in the mulched coffee leaf samples whereas calcium, magnesium and to a lesser extent sodium levels were consistently lower in the mulched coffee leaf samples.

Nitrogen Fertilizer (*a*).—A comparison of leaf ntirogen values (first fully open leaf pair) in untreated and nitrogen fertilizer treated coffee is illustrated in Figure II. The effect of 46 lb. of nitrogen applied as urea or sodium nitrate in April was to increase the leaf nitrogen level in the September/October samples taken during the hot, dry drought period towards the end of crop maturation. With the onset of the short rains in November/December, this difference diminished rapidly.

Nitrogen Fertilizer (*b*).—The influence of sodium nitrate fertilizer on the composition of the first fully open coffee leaf was examined by collecting monthly leaf samples from April through December, 1959. The sodium nitrate fertilizer had been applied to this coffee annually for nine years prior to sampling. The results obtained for sodium, potassium, calcium, and magnesium in the leaf samples are summarized in Figure VII. The coffee was not mulched.

Fig. VII.—A comparison of changes in leaf composition for coffee ± sodium nitrate



The overall mean increase in the level of sodium and decrease in the level of potassium in the leaves from the sodium nitrate treated coffee compared with the untreated control, were statistically significant (control = 0.040, sodium nitrate = 0.052% Na and control = 2.60, sodium nitrate = 2.33% K in leaf dry matter. L.S.D.'s Na=.008%; K=0.24%). There is a strong suggestion that the leaf magnesium level was increased following sodium nitrate application (compensation for decreased potassium perhaps?), whereas the leaf calcium level does not show any particularly marked difference.

Summary and Conclusions

1. Leaf analysis results are presented to illustrate some effects of the age of the leaf sample collected on the contents of potassium, calcium and magnesium in mature, bearing coffee growing on the Kikuyu red loam coffee soil. When the analyses were expressed as a percentage of the element in the leaf dry matter potassium and magnesium values were found to be both higher or lower in the fourth mature leaf than in the first fully open leaf; under certain conditions potassium values may increase steadily with increased age of the leaf; calcium values were found to be higher in the older leaves.

2. When the same results were expressed in milli-equivalents concentration, each element as a percentage of the sum of the three elements, i.e. potassium + calcium + magnesium, concentrations of potassium and magnesium were consistently less in the fourth mature than in the first fully open leaf pairs whereas the calcium concentrations was much higher in the older leaf sample.

3. The position of the leaf on the tree influences the analytical values found for potassium, calcium and magnesium. The side of the tree from which the leaf sample was collected affected significantly the leaf potassium values; samples taken from the top or bottom half of the tree showed significant differences for the calcium and magnesium levels in the leaf. These differences were probably due to radiation intensity, the quantity of maturing crop present and the amount of vegetative growth produced.

4. Examples of seasonal variation, expressed as percentage of the element in leaf dry matter, for nitrogen, phosphorus, potassium, calcium and magnesium are given. Generalizing very broadly in mature bearing coffee nitrogen, phosphorus and potassium levels in the first open and fourth mature leaves are at a minimum in the months of September/October, i.e. in the hot, sunny, dry months following the dull and cool but dry winter months, during the latter stages of crop maturation and harvest. Calcium values may also exhibit similar variation; magnesium values are not consistent but are frequently found to be at their lowest rather earlier in the year, i.e. in the winter months of July/August.

5. It was observed in one long-term experiment that when the potassium and calcium contents in the first open leaves were expressed on a proportional concentration basis, calcium changes appeared to be compensatory to potassium changes, i.e. calcium increased steadily as potassium decreased steadily in the leaf. Magnesium trends also showed a regular pattern.

6. Some effects of Napier grass mulch, urea and sodium nitrate fertilizer applications on coffee leaf composition are described.

7. It is apparent from these preliminary results that whilst the leaf analysis technique can be a very useful tool in the arbitrary study of coffee nutrition, considerable research is necessary to establish a basis for logical interpretation. It is necessary to establish relationships between observed leaf values and yield, climatic season, growth periods, crop maturation, leaf age and cultural practices before detailed interpretation will be possible.

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REVIEWS

DIET IN RELATION TO REPRODUCTION AND THE VIABILITY OF THE YOUNG: PART III. Tech. Comm. 21. Commonwealth Bureau of Animal Nutrition. Published by the Commonwealth Agricultural Bureaux, Slough, Bucks., England. 106 pp. Price 20*s*.

This is an excellent review of the present state of our knowledge concerning the diet of pigs as it affects reproduction and the viability of the young. It is addressed mainly to the research worker and it should be read by all concerned with pig experiments. There is a good list of references and a satisfactory subject index.

CONSEQUENCES OF DISTURBANCE, by Alan Mozley, published by H. K. Lewis and Co. Ltd., London, 1960. 55 pp. Price 9*s*.

The author points out that one of the consequences of disturbance may be pests and that pest control might be achieved more simply by studying the underlying causes, in particular disturbance. He discusses in very general terms the very complex situations which arise when growing crops of plants or animals and suggests the need for the exercise of judgment and nice discrimination among the weapons used in pest control.

In all this is a plea for "community ecology", a study of whole communities and the fragments which remain after disturbance.

THE CULTURE OF TILAPIA NIGRA (Günther) IN PONDS

VII—SURVIVAL AND GROWTH OF TAGGED AND UNTAGGED MALES OF DIFFERENT SIZES

By V. D. van Someren and P. J. Whitehead, Fisheries Division (Research), Ministry of Forest Development, Game and Fisheries, Kenya Colony

(Received for publication on 2nd March, 1960)

In Parts I to VI of this series of papers, frequent reference has been made to the use of tagging techniques for the recognition of individual fish in various pond experiments. The actual techniques used have been described elsewhere (van Someren and Whitehead, 1959). It was stated in these previous papers that tagging appeared to have no appreciable effect on growth, but the question of survival of tagged, as against untagged, fish had not yet been considered.

At the same time, reference was also made to the differing growth rates of small and large fish stocked in the same pond, the smaller fish appearing to grow faster during the same period. This has been explained as being due to the fact that the growth curve of *T. nigra* is not regular, but asymptotic, and thus steep in the earlier growth period and flattening out later. Thus at equivalent stocking rates, the smaller fish appear to grow faster, since they are at an earlier, steeper, part of the curve, than larger fish whose rate of growth is already slowing down. It should be understood that this applies only to the growth in length, not to the weight increase.

The present paper describes the results from a more critical experiment carried out to determine the effect of tagging in relation to growth and survival, utilizing two different sizes of males stocked simultaneously into one pond.

METHODS

This experiment was carried out at the Inland Fishery Research Station of this Ministry at Sagana, utilizing the half-acre pond labelled A2 in Part II of this series. This is a reasonably good growing pond with relatively clear water, fish in a previous experiment having reached a length of 21.0 cm. in six months at a stocking rate of 200/acre, when grown in water held at an average depth of two feet.

In the present experiment the stocking rate utilized was also 200/acre, but the water level was held at 1 ft. average depth, growth being better in such shallow water (Part II). The 100 fish stocked were males only, sexed by genital examination, and they comprised two lots of 50 fish each, of two widely differing size groups. The 50 smaller fish averaged 7.5 cm. total length at stocking, the 50 larger fish 13.0 cm. total length on stocking. In order to eliminate as much variability in growth as possible, the individual fish of each lot were most carefully selected so that the total range in sizes of each lot did not vary by more than 2.0 mm. either way of the average length of the two groups.

These two groups of 50 fish each were further subdivided equally, and 25 of each group were tagged with silver wire plastic tags at the forward base of the dorsal fin as in the standard technique, the needle being sterilized in spirit between each operation. The remaining 25 fish in each lot remained untagged, and all fish were stocked simultaneously. Handling during sexing was kept to the minimum required, though the tagging of the 50 fish involved additional handling of this lot.

Commencing one month after first stocking, the pond was seined with a ½-in. mesh nylon seine at more or less regular monthly intervals, all the fish in one haul being measured to the nearest millimetre total length and returned alive to the pond with minimum delay.

At the ninth month after stocking the pond was drained down, all surviving fish being counted and measured. Up to this ninth month it still remained relatively easy to separate even the untagged fish into their respective stocking groups on the basis of size, and no tags ever became detached from any of the marked fish. Thus completely accurate figures for survival and growth of both batches were obtained.

RESULTS

These are shown diagrammatically in Fig. 1 and appear perfectly clear cut.

Survival.—The total count on final drainage showed that of the larger size groups stocked, 84 per cent and 87 per cent of the tagged and untagged fish respectively had survived after nine months. The difference does not appear significant, thus demonstrating that fish can be safely tagged by this method at a size of 13.0 cm. (and probably above), without in any way affecting their chances of survival. This survival rate is slightly higher than that found in previous experiments; but no matter what care is taken over first stocking even with fish of this size, it does not seem possible to achieve a 100 per cent survival of all fish stocked, and some allowance for anything from a 10-20 per cent loss of fish should be made if trying to achieve a fixed stocking rate.

In the second part of Fig. 1 the percentage netting recoveries are shown for each month previous to final drainage. These have been calculated on an assumption of 100 per cent survival up to the eighth month, but on corrected figures for final survival it would appear that one net haul recovered up to 80 per cent of fish actually present at any time; though as mentioned in a previous paper this netting efficiency must vary a good deal from month to month depending on the skill of the labour employed.

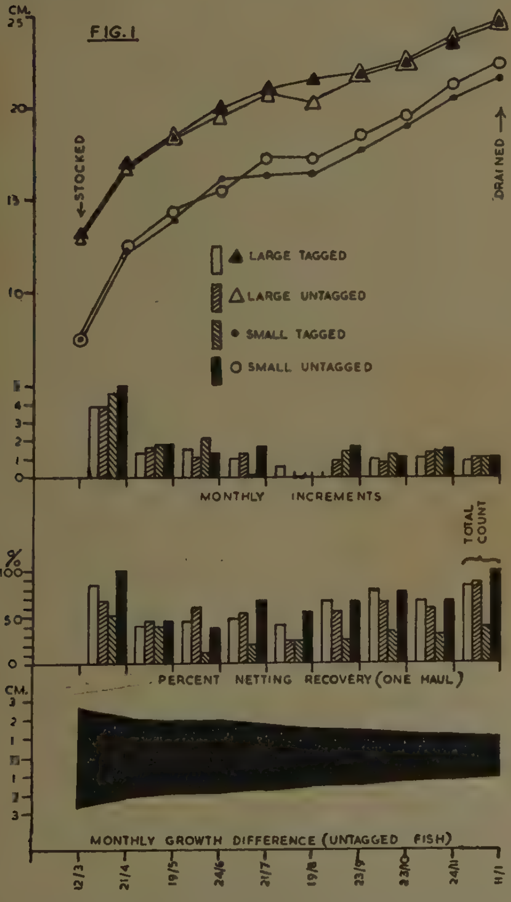

Fig. 1.—Growth and survival of tagged and untagged male *T. nigra* of two different size groups stocked simultaneously in the same pond

It seems likely, however, from these figures that the major mortality occurred in the first month after stocking, as has been suggested previously. This mortality is almost certainly due entirely to handling, since natural predation, by birds for example, would be more evenly spaced over the months. It is certainly a fact that after a pond is stocked, it is often possible to pick up a few dead fish within the first two or three days after stocking, though thereafter dead fish are rarely seen.

In the small size group stocked, however, there is a wide and significant discrepancy in the survival of tagged and untagged fish, 40 per cent and 100 per cent respectively. There seems no question that tagging, or the additional handling consequent on tagging will seriously affect the chances of survival of fish as small as 7.5 cm. It is again clear from the monthly netting recoveries that these small tagged fish must have died within the first month after stocking, since recoveries of this group were consistently lower every month than those of other fish. Within broad limits, the figure shows that seine netting recovered each lot of fish roughly in the proportions in which they were in the pond, and there is little bias in the recovery figures for either size or tagging.

It is also likely, however, that the figure of 100 per cent survival of small untagged fish is too high, although probably correct for the first monthly netting. In this first month's netting it was found that one of the larger untagged fish had been wrongly sexed and was a female. Although she was destroyed at once, it was known that she had spawned once in this first month, for a few of her progeny were found in the next month (and are unccunted in the recovery figures). These progeny were also immediately destroyed, but it seems likely that a very few had escaped the netting each month and survived to the ninth month, by which time they had grown also to the size of the smaller untagged fish, a growth rate which is perfectly possible. In fact, 26 untagged fish of the small group were recovered on final drainage, not 25, thus indicating that at least one or perhaps a few more fry had survived in numbers sufficient to cover up what natural mortality had occurred amongst the original small untagged fish stocked, thus raising the survival to an unnaturally high figure which has not been found previously.

Growth.—The curves in the upper part of Fig. 1 show that for the larger fish the growth of both tagged and untagged fish was practically identical each month. The small variation of a millimetre or so each way was probably due to sampling differences, as is the apparent drop in growth of large untagged fish shown in August; this is clearly due to an insufficiently large-sized sample being netted in that month to give a true average. It appears therefore that tagging fish of 13.0 cm. (and above) in this fashion, also in no way affects their future growth.

For the small fish, however, it is apparent that from the fourth month the growth rate of the tagged group dropped and remained consistently lower than that of the similar size untagged fish. After this drop, they appeared unable to catch up again, and it is probable that while tagging of small fish may not necessarily at first affect their growth rate, nevertheless if growth is adversely affected thereafter for any reason, the additional handicap of tagging at this size may preclude resumption of normal growth thereafter.

In this experiment, such adverse circumstances did exist. As shown in Part IV of this series, *T. nigra* at Sagana show seasonal growth cycles related mainly to swings in mean water temperature; one of the seasons for such minimal growth is the dull, cloudy months of July-August. It will be seen from these curves that all the fish in this experiment showed this reduced growth at that time, growth being slowed between 24/6 and 19/8, thereafter accelerating again. The temperature régimes for this period are in fact those shown in Part IV, the experiments being concurrent. However, the small tagged fish were depressed further in their growth than the untagged fish during this period, and although by then of a size larger than the larger group of fish on first tagging, were still unable to accelerate sufficiently to recover this loss.

It is very likely that tagging fish at such a small size imposes a physiological strain on them for repair of wounded tissue, which may be without an obvious effect as long as growing conditions are optimal. Larger fish appear to be able to withstand this strain without adverse effect, even when the environment is more unfavourable.

The lower part of Fig. 1 shows the same phenomenon of "convergent" growth of different sized fish as has been noted before. This convergence is nothing to do with tagging, but is purely a function of the size at which a fish is first subject to improved growth conditions as found in monosex culture. The growth is only apparently faster in small fish, and is a function of their younger age and greater length-growth potentiality at such younger ages. In this present experiment, the size difference on first stocking was made deliberately large, but there is no doubt that both size groups, if left, would have reached the same asymptotic size in this pond, for in nine months a 5 cm. difference had narrowed to 2 cm. as is shown for the untagged fish in each group. This diagram shows results for untagged fish only, since tagging of the smaller fish had affected their growth in any case. Part V of this series has already shown that when stocked simultaneously there is no marked mutual effect on growth between small and large fish, though such an effect is marked when stockings of different size groups are spaced in time.

SUMMARY

Individual tagging of fish of sizes from 13.0 cm. upwards does not have any effect on either their subsequent growth rate or survival. Tagging of fish as small as 7.5 cm., however, appears to affect adversely both their chances of subsequent survival and their growth rate if environmental conditions are not optimal.

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LEAF COMPOSITION OF SOME TROPICAL CROPS

By W. E. Calton (1), J. W. Vail (2) and V. P. Padhye (Department of Government Chemist, Tanganyika)

(*Received for publication on 23rd December, 1960*)

The data given in this paper are those, not published elsewhere, which have accumulated during the period 1953 to 1959 in the investigation of unthriftiness in various crops grown in Tanganyika. This type of work has now ceased in the Department and the data may be useful to other workers in this field and of interest to farmers growing the crops mentioned.

PRESENTATION OF RESULTS

The figures are total contents of nutrient elements in the leaf dry matter. Those boxed under one crop heading are closely comparable, the thrifty and unthrifty being bulk samples of the same type of leaf collected at the same time or times in the same locality. Where data are also given on the flourishing crop this sample, though comparable as to type of leaf and time of sampling, comes from another locality with undoubtedly highly fertile soils. The comparable thrifty and unthrifty samples derive from the same general type of soil though in a few cases there are drainage differences. Some of the data, which it would have been difficult to present in full, are averages of monthly samples collected over a period of time. They show the general level of nutrients associated with thriftiness and the more persistent differences between thriftiness and unthriftiness. The ranges of the nutrients averaged are not given as there are definite indications of seasonal trends in nutrient levels and it would be misleading to suggest that there is random variation around "normal" values. The more significant results are underlined.

NUTRIENT LEVELS IN THE THRIFTY CROPS

Levels of phosphorus (P), sulphur (S) and magnesium (Mg) are remarkably constant. Calcium (Ca) levels are amongst the most variable and agree generally with crop preferences for calcareous or acid conditions. Boron (B) levels differ, as is well known, between monocotyledons and dicotyledons. Specifically, there are indications of fairly normal demands for nutrients in bananas except B which is low. The beans show a low manganese (Mn) uptake but this may be due to soil—other crops in this locality have shown Mn deficiency. Cashew appears to be a low Ca demander and macro-nutrients, except P, have a tendency to be low. Coconut shows a low level of macro-nutrients except S. Coffee has fairly normal nutrient demands though nitrogen (N) and boron are rather higher than usual. Grapes show a high Ca demand while groundnuts tend in that direction. Maize and millet do not show any marked nutrient peculiarities except low B values. Possibly millet can tolerate rather low N supplies. Pine seedlings need little Ca but they can also take up large amounts and remain healthy. Mature pines also show low Ca levels and the general level of macro-element nutrition is not high. Pyrethrum has relatively high demands for such macro-nutrients as N, K, S, Ca and Mg. Rice and sugar cane show relatively low B and macro-nutrients except P and S (low Mn uptake in the latter may be a soil factor). Sorghum is rather similar but shows high N uptake. Teak shows surprisingly high Ca and except for Mg, B and Cu, a low level of other nutrients. The tobacco shows high K and Mg levels.

NUTRIENT VARIATION IN UNTHRIFTINESS

The unthrifty conditions investigated show in the case of bananas little difference between thrifty and unthrifty in the young leaf though there is a suggestion of Ca shortage in the latter. In the mature leaf there is K shortage in the unthrifty while in the thrifty there are indications of a drain on P and perhaps B during fruiting. In the "oily pod" beans Cu is down but this is likely because of soil conditions and it cannot be taken that the disease is Cu deficiency without further investigation. In the cashew there is reduced N, P, K and raised Fe, Mn, Cu in the unthrifty. This is possibly due to unfavourable physical conditions of the soil—wetness, which this crop does not like, perhaps increasing Fe, Mn, Cu uptake and interfering with macro-nutrient nutrition. The indications given by the coconut leaf analyses are not clear, possibly K and S are involved in the "taper point" condition. The robusta coffee shows a curious abnormality—raised P in the unthrifty. This is possibly due to deficiency of an undetermined micro-nutrient; the soil is not high in P. In arabica coffee a number of unthrifty conditions have been studied. In the first set of results comparing thrifty with three unthrifty samples the unthrifty show clearly shortage of P, K, Ca and Mg while Fe, Mn and Cu are raised. This site had been exhaustively cropped and with the loss of exchangeable bases from the soil and the shift of reaction to greater acidity there are less bases and more Fe, Mn and Cu available for uptake. In the second set comparing the coffee showing deficiency symptoms with flourishing coffee there are indications of Ca and B shortages. The symptoms were traced to B, Zn deficiencies by the analysis of young leaf and were cleared up in the field with B—Zn sprays. The sprays however brought on Mg deficiency and at this site nutritional difficulties are considerable involving at least B, Zn, Ca and Mg. In the third set there is clearly Mn shortage in the unthrifty and high uptake of K, which could be expected from soil conditions, exchangeable K being very high. It is possible that high K has depressed Mn uptake. In the fourth set comparing three lots of coffee with green and yellowing leaf the yellowing is plainly due to N shortage, though N levels still remain reasonably high. B levels are consistently up in the yellow and there might be N/B unbalance. In the final set of arabica coffee figures the analysis confirms Mn deficiency. As in the third set of figures K is very high.

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In the Eucalyptus seedlings there are fairly clear indications that unthriftiness is due to Cu toxicity. They had in fact been excessively treated with a Cu fungicide against "damping off" disease and the unthrifty were stunted and discoloured. There is the suggestion that high N uptake is associated with Cu toxicity. The unthrifty grapes show markedly lower K, Ca and Mg with very high Cu. The soil they were growing in was in fact much lower in exchangeable bases than the thrifty soil and this probably explains the unthriftiness. The high Cu may be a local soil peculiarity as there are no records of Cu treatment. The groundnut samples show comparatively low P and S in the unthrifty. In the three sets of maize leaf analyses the first gives indications of Mn and Cu shortages in the unthrifty, in the second no significant differences appear in the nutrients determined, while in the third a range of nutrients—N, K, Mn and B—are low and Mg may be borderline in both the thrifty and unthrifty. The unthrifty millet suggests Mn toxicity and the soil was in fact very acid. The Olea seedlings show no significant differences and the cause of the unthriftiness is unexplained. Soil salinity is a possibility and the tendency for Ca and Cu to be low in the unthrifty supports this. In the pine seedlings the first two pairs shows P deficiency and a similar derangement of other nutrients—lowered N with most other nutrients raised. The third pair suggest Cu toxicity and in fact excessive amounts of a Cu fungicide had been used. As with the Eucalyptus there is high N in the high Cu seedlings. The grown pines show Ca, Mg and B shortages and raised Fe, Mn. The soil was very acid and B deficiency is prevalent in other crops in this locality.

In the first series of pyrethrum leaf analyses the only element of those determined which gives any suggestion of relation to yield is S. In the third pair the very unthrifty shows marked nutrient derangement. There is P deficiency and probably Mn toxicity. Further, separation of these samples into young and old leaf showed B deficiency in the young leaf of the very unthrifty. The main sample of the very unthrifty also shows K shortage and raised Ca, Mg. The soil was very acid which explains the high Fe, Mn uptake. The raising of Ca, Mg is possibly connected with P deficiency, by analogy with the P deficient pine seedlings. The pyrethrum "blinds" were analysed to find out whether the lack of any nutrient affected flowering. There is compared with flourishing pyrethrum somewhat lower S. The last two pyrethrum samples, both unthrifty, are from an acid crop-exhausted site. They show, as could be expected, lowered Ca and K and raised Fe.

The "blind ear" rice shows comparatively low S and Cu. Sorghum is another case in which interest is directed to deficiency of an undetermined micro-nutrient or trace element toxicity. Analysis confirms K shortage in the sugar cane and Ca and Mg are also lowered. The cause of this was apparently rather high exchangeable Na in the soil and the symptoms disappeared with gypsum treatment and leaching. The teak analysis shows in the unthrifty reduced Ca and very high Mg uptake, suggesting partial substitution of Mg for Ca in Ca shortage. In the tobacco the only element of those determined which may be significant in the brittle leaf condition is Cu.

CONCLUSIONS

It is clear that leaf analysis is a useful technique in the study of plant nutrition problems in that gross nutrient shortage or excess can easily be detected and deficiency or toxicity symptoms confirmed. In symptomless unthriftiness interpretation of the analysis is more difficult. There appears to be a slowing up rather than a breakdown of plant functions caused either by a low rate of supply of particular nutrients or unbalance of nutrients. There is possibly some adaptibility in the plant to nutrient shortage with partial substitution say among the macro-nutrient cations and the catalytic elements which assists survival. As to specific nutrient demands of crops dicotyledons clearly require more B than monocotyledons while it is likely that there are fairly specific demands for Ca *vis-a-vis* Fe. The commonest cause of crop unthriftiness in Tanganyika is macro-nutrient cation shortage, either arising naturally from the advanced state of weathering of many of its soils or induced by exhaustive cropping. Leaf analysis would probably be more useful if more reference information was available on the flux of nutrients in the leaf of crops under the most favourable conditions of nutrient supply and environment.

NUTRIENT ELEMENTS IN THE LEAF DRY MATTER OF COMPARABLE SAMPLES OF VARYING THRIFTINESS

BANANA

	(*a*) YOUNG LEAF		(*b*) MATURE LEAF DURING FRUITING									
	Thrifty	Unthrifty	Thrifty					Unthrifty				
%			1	2	3	4	5	1	2	3	4	5
N	2·92	2·99	2·80	2·33	2·45	2·42	2·42	2·00	2·93	3·18	2·42	1·98
P	0·28	0·25	0·28	*0·15*	*0·17*	*0·15*	0·15	0·26	0·22	0·20	0·17	0·14
K	2·91	2·95	2·10	2·16	2·50	2·30	2·27	2·50	*1·52*	*1·52*	*1·49*	*1·49*
Ca	0·52	*0·46*	0·76	1·08	0·72	1·19	1·14	0·61	0·52	1·23	1·23	1·41
Mg	0·34	0·32	0·36	0·33	0·28	0·48	0·43	0·64	0·29	0·37	0·44	0·36
S	0·21	0·18	0·18	0·21	0·15	0·21	0·21	0·16	0·18	0·21	0·20	0·22
ppm												
Fe	43	48	82	85	209	99	217	106	57	204	208	247
Mn	136	166	312	339	388	384	417	442	283	326	539	463
Cu	15	17	9	13	11	9	11	8	11	27	11	10
B	9	7	6	8	6	*2*	*3*	6	7	5	4	6

(*a*) Averages of 10 samples. (*b*) Averages of 2 samples.

	BEANS		CASHEW		COCONUT	
	Healthy	"Oily pod"	Thrifty	Unthrifty	Healthy	"Taper point"
%						
N	2·8	3·3	1·98	*1·52*	0·91	1·07
P	0·26	0·26	0·21	*0·10*	0·11	0·10
K	3·1	3·6	1·69	*0·97*	0·82	*0·66*
Ca	0·55	0·62	0·09	0·16	0·26	0·34
Mg	0·39	0·43	0·20	0·17	0·12	0·18
S	0·15	0·18	0·15	0·14	0·39	*0·23*
ppm						
Fe	119	146	45	*95*	190	160
Mn	24	25	95	*260*	395	440
Cu	73	*10*	16	*66*	13	13
B	22	50	9	10	38	35

	COFFEE (robusta) (*c*)		COFFEE (robusta) (*d*)		COFFEE (arabica)			
	Thrifty	Unthrifty	Thrifty	Unthrifty	Thrifty	Unthrifty	Unthrifty	Unthrifty
%								
N	3·18	3·12	3·31	*2·78*	2·37	*2·77*	2·88	2·60
P	0·19	*0·29*	0·15	*0·50*	0·21	*0·09*	*0·10*	*0·14*
K	2·19	2·36	2·07	2·23	2·48	*2·19*	*1·44*	*1·34*
Ca	0·67	0·77	0·79	0·77	0·97	*0·65*	*0·76*	*0·81*
Mg	0·29	0·33	0·33	0·37	0·55	*0·22*	*0·14*	0·61
S	0·19	0·20	0·22	0·19	0·14	0·21	0·21	0·36
ppm								
Fe	93	66	130	120	356	*573*	*525*	*439*
Mn	75	80	106	101	158	*400*	*624*	*224*
Cu	23	29	30	35	42	*60*	*88*	33
B	24	23	34	20	n.d.	44	51	59

	COFFEE (arabica) (*e*)			COFFEE (arabica) (*f*)			
	Better	Poorer	Flourishing	Flourishing (tip leaves)	Flourishing (2nd pair)	Unthrifty (tip leaves)	Unthrifty (2nd pair)
	(with deficiency symptoms)						
%							
N	2·40	2·58	2·52	2·82	2·98	2·98	3·08
P	0·14	0·15	0·14	0·23	0·21	0·24	0·21
K	2·14	2·33	2·15	3·1	2·98	*3·38*	*3·72*
Ca	*0·91*	*0·74*	1·28	0·92	0·85	0·68	0·66
Mg	0·48	0·51	0·43	0·42	0·45	0·34	0·41
S	0·08	0·14	n.d.	0·23	0·23	0·21	0·21
ppm							
Fe	n.d.	n.d.	n.d.	122	102	103	108
Mn	148	130	83	48	44	*17*	*19*
Cu	22	24	25	27	28	33	29
B	*34*	*38*	53	28	28	26	26

(*c*) Averages of 12 samples.
(*d*) Averages of 7 samples collected later from same trees as (*c*).
(*e*) Averages of 14 samples.
(*f*) Averages of 5 samples.

	COFFEE (arabica)						COFFEE (arabica)
	Green	Yellow	Green	Yellow	Green	Yellow	Showing Mn def. symptoms
%							
N ..	2·68	*2·20*	3·48	*2·47*	2·23	*2·16*	3·27
P ..	0·13	0·14	0·16	0·14	0·17	0·16	0·20
K ..	2·34	2·29	1·58	1·57	1·85	1·59	*4·13*
Ca ..	1·51	1·48	1·58	1·51	0·89	1·87	1·46
Mg ..	0·29	0·24	0·22	0·19	0·19	0·18	0·57
S ..	0·22	0·17	0·20	0·20	0·19	0·23	0·27
ppm							
Fe ..	116	108	118	90	70	139	129
Mn ..	59	45	49	28	33	42	*13*
Cu ..	58	55	36	27	144	334	320
B ..	22	*40*	26	*37*	14	*48*	40

	EUCALYPTUS (seedlings)				GRAPES			
	Thrifty	Unthrifty	Thrifty	Unthrifty	Thrifty	Unthrifty	Thrifty	Unthrifty
%								
N	2·14	*4·60*	3·74	n.d.	1·18	*1·67*	2·6	3·0
P	0·22	0·27	0·32	n.d.	0·21	0·25	0·21	0·19
K	1·43	1·41	2·43	2·28	0·58	0·68	2·22	*1·53*
Ca	0·90	1·00	1·19	0·98	1·08	1·08	2·24	*0·94*
Mg	0·52	0·60	0·57	0·52	0·38	0·52	0·56	*0·26*
S	0·17	n.d.	0·14	n.d.	0·16	0·18	0·22	0·26
ppm								
Fe	113	154	670	535	443	354	95	89
Mn	270	285	717	920	208	241	14	58
Cu	35	*148*	138	*334*	24	*34*	8	*344*
B	22	n.d.	8	n.d.	16	18	37	38

	GROUNDNUTS		MAIZE		MAIZE		MAIZE	
	Thrifty	Unthrifty	Thrifty	Unthrifty	Thrifty	Unthrifty	Thrifty	Unthrifty
%								
N	4·1	4·3	3·0	2·1	2·7	2·7	1·97	*1·40*
P	0·39	*0·11*	0·40	0·39	0·21	0·20	0·15	0·16
K	2·1	1·8	1·71	1·89	1·2	1·1	2·62	*1·98*
Ca	1·6	1·4	0·34	0·45	1·2	1·4	0·22	0·23
Mg	0·71	0·41	0·19	0·28	0·38	0·45	0·08	0·08
S	0·41	*0·11*	0·23	0·24	0·25	0·52	0·12	0·10
ppm								
Fe	1,010	*1,750*	55	70	232	174	74	92
Mn	93	*185*	16	*9*	108	101	69	*29*
Cu	27	30	43	*12*	31	24	14	12
B	68	*43*	6	11	17	20	13	*1*

	MILLET		OLEA sp. (seedlings)		PINE (seedlings)					
	Thrifty	Unthrifty	Thrifty	Unthrifty	Thrifty	Unthrifty	Healthy	Dying	Healthy	Dying
%										
N	1·06	1·40	1·94	1·84	2·30	*1·88*	2·53	*2·22*	1·19	*1·79*
P	0·30	0·27	0·14	0·15	0·20	*0·14*	0·34	*0·06*	0·29	0·25
K	1·91	2·24	1·93	1·87	1·50	1·62	1·79	*4·92*	1·66	1·78
Ca	0·91	0·84	1·26	0·95	0·20	*0·35*	1·32	*1·71*	0·30	*0·94*
Mg	0·18	0·11	0·20	0·21	0·15	*0·41*	1·25	*1·34*	0·15	*0·40*
S	0·21	0·16	0·22	0·15	0·29	0·27	0·12	*0·23*	n.d.	n.d.
ppm										
Fe	160	*270*	240	360	580	*700*	725	*4,930*	754	*1,380*
Mn	220	*1,420*	33	35	46	*60*	92	*182*	92	60
Cu	9	11	17	*8*	14	*37*	84	77	15	*715*
B	1	1	12	13	12	*24*	20	*31*	11	*28*

	PINES		PYRETHRUM (*g*) Decreasing in yield from left to right						
	Thrifty	Unthrifty							
%									
N	1·94	1·74	3·1	2·8	3·1	2·9	2·9	2·9	2·9
P	0·13	0·12	0·16	0·15	0·17	0·20	0·18	0·15	0·11
K	1·05	0·91	4·0	3·6	3·2	3·4	3·6	3·4	3·0
Ca	0·27	*0·17*	0·77	0·66	0·64	0·73	0·68	0·76	0·64
Mg.. ..	0·18	*0·11*	0·39	0·39	0·44	0·33	0·41	0·31	0·35
S	0·16	0·19	*0·38*	0·30	*0·36*	*0·36*	*0·33*	*0·28*	*0·27*
ppm									
Fe	149	*278*	330	400	270	330	330	370	300
Mn ..	336	*508*	140	130	150	190	210	120	180
Cu	8	8	20	14	14	20	16	20	17
B	9	*4*	12	14	19	15	17	16	16

	PYRETHRUM		PYRETHRUM		PYRETHRUM		
	Flourishing						
	High yield	Very high yield	Thrifty	Very unthrifty	"Blinds" (non-flowering plants)		
%							
N	3·8	3·27	2·99	2·78	2·38	2·19	2·83
P	0·34	0·23	0·11	*0·03*	n.d.	n.d.	n.d.
K	3·5	*5·82*	3·14	*1·34*	3·07	2·82	3·29
Ca	1·1	*1·40*	0·58	*1·03*	0·85	0·61	0·70
Mg	0·22	0·46	0·29	0·55	0·43	0·50	0·50
S	0·33	0·36	0·29	0·35	*0·22*	*0·23*	0·28
ppm							
Fe	900	1,010	245	*453*	653	683	374
Mn	100	720	96	*1,000*	167	276	135
Cu	19	22	13	*28*	41	25	23
B	32	24	18	20	26	25	16

(*g*) Averages of 10 samples.

	PYRETHRUM		RICE		SORGHUM	
	Unthrifty	Unthrifty	Healthy	"Blind ear"	Thrifty	Unthrifty
%						
N	3·47	3·47	1·3	2·0	2·4	3·1
P	0·19	0·31	0·24	0·22	0·16	0·23
K	*2·90*	*2·75*	0·75	0·76	1·2	1·5
Ca	*0·68*	*0·49*	0·16	0·12	0·54	0·72
Mg	0·26	0·34	0·18	0·20	0·16	0·23
S	0·36	0·35	0·32	*0·19*	0·22	0·22
ppm						
Fe	*1,390*	*1,680*	147	124	166	170
Mn	122	120	256	202	33	42
Cu	28	35	10	*6*	16	13
B	28	28	1	1	14	11

	Sugar Cane		Teak		Tobacco	
	Healthy	K deficiency symptoms	Thrifty	Unthrifty	Normal leaf	Brittle leaf
%						
N	0·86	1·31	1·50	1·68	n.d.	n.d.
P	0·19	0·22	0·11	0·18	n.d.	n.d.
K	1·34	*1·14*	0·88	0·91	3·9	4·1
Ca	0·65	*0·30*	3·19	*2·70*	0·96	0·84
Mg	0·21	*0·11*	0·33	*0·74*	0·58	0·54
S	0·20	0·62	0·07	0·12	0·29	0·42
ppm						
Fe	410	520	77	128	386	352
Mn	37	27	33	24	404	427
Cu	62	74	21	15	27	*11*
B	7	8	34	68	11	25

REVIEW

Taxonomy of Flowering Plants, by C. L. Porter, published by W. H. Freeman and Co., San Francisco and London, 1959, pp. 452 (600 illustrations). Price 44*s.* and $6.75.

This is a well-produced book giving an elementary but excellent introduction to the history, principles and methods of angiosperm taxonomy. Brief descriptions, with illustrations, are given of just over 100 flowering plant families. It is particularly intended as a text-book for "undergraduate students in such practical fields of study as agronomy, range management, forestry and wildlife management and conservation", but is equally suitable for all those who are studying botany and for teaching in schools.

The text has been divided into three major parts. The first deals with the history, principles and methods of plant taxonomy and includes brief discussions of the work of botanical scholars from Theophrastus to Eams and Bailey; the use of manuals, floras, indices and catalogues; field and herbarium methods; and an excellent introduction to plant nomenclature, concepts of classification, the construction and use of keys for identification and the terminology of plant description.

The last two parts deal with the taxonomy of the angiosperms, Part II treating the orders and families of monocotyledons arranged according to Hutchinson, and Part III the order and families of dicotyledons arranged according to Bessey. Family descriptions, drawings and floral diagrams are included, as well as charts comparing the characteristics of related families. Numerous photographs have been chosen to illustrate particular points and family characteristics.

The treatment of the Brassicaceae (Cruciferae) and Apiaceae (Umbelliferae) is perhaps on the meagre side when compared with that given to other large families. It is unfortunate also that many of the terms used to describe types of inflorescence have been included, for although correct, they are seldom met with today. The illustrations are good, although the reproduction of some of the photographs is poor. The book is well indexed and there is a very good glossary. Each chapter has a useful list of references at the end.

This text-book may, therefore, be recommended to all interested in any aspect of systematic botany, for it fills the gap which has long existed between the advanced treatise and schoolroom notes.

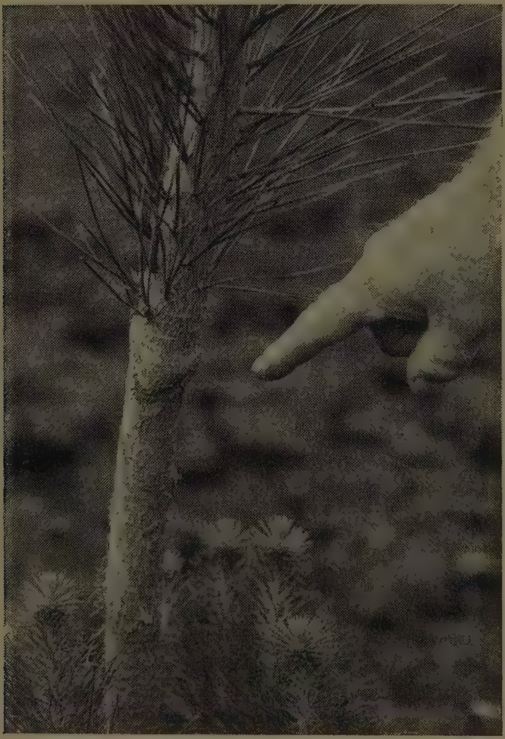
M.D.G.

A TECHNIQUE FOR GRAFTING CONIFERS IN THE FIELD IN EAST AFRICA

By W. B. May, East African Agriculture and Forestry Research Organization, Muguga, Kenya

(Received for publication on 17th January, 1961)

During the past ten years much interest has been shown in the grafting of conifers in many countries. Mexican and other fast-growing Pines have been widely planted during this period in Africa and Australasia: in East Africa the chief species being *Pinus radiata* and *Pinus patula*. The stage has been reached where it is highly desirable to select superior trees, and bring them together to form seed orchards. It is for this purpose the use of grafting is employed.



In East Africa at no time of the year do these fast-growing pines enjoy a period of rest. This proved a distinct disadvantage when grafting by normal techniques. After a considerable amount of experimentation, the following top cleft technique has repeatedly given a very high percentage of success, irrespective of the time of year when the operation has been carried out.

Stock

Young transplants from the nursery are field planted at seed orchard spacing during the normal planting period. An application of fertilizer at time of planting is desirable, and a heavy mulch should be applied before the rainy season ends. Some three months after planting these young transplants should be growing vigorously and should preferably, from a grafting point of view, be not more than 16 to 18 in. high.

Scion

The scion material should be terminal shoots, leading shoots of side branches are preferable to second or third order shoots as the former make a tree more quickly and easily than the latter. The material must be soft and growing, but not when the terminal bud has just "shot" (suddenly elongated).

Grafting Operation

The stock is decapitated some two to three inches below the apical bud, the needles are then carefully stripped off for about three inches.

The scion is then cut to approximately three inches in length, the needles are carefully stripped off the scion leaving about a one-inch tuft of needles surrounding the apical bud. Should these needles be very long, they can be shortened. All cuts are made with an ordinary safety-razor blade.

Cut the stock down the centre of the stem for about 1½ in.

The scion is then cut wedge shape a similar length to fit the cut made on the stock.

The wedge shape scion is then inserted into the stock, cambial contact must of course be made, and the writer has found it far more satisfactory to endeavour to match one side of the scion and stock only, rather than to try and make a perfect match. The graft is then securely tied with wet raffia.

Speed in this operation is absolutely essential otherwise a resin layer forms between the two cambial layers thus preventing a union. Indeed not more than half a minute should elapse from the moment of the first cut.

A piece of 6-in. wide 150-gauge polythene tubing is then slipped over the graft and the bottom end tied below the graft. A little clean water (about 10 c.c.) is squirted into the tube, the tube is then inflated by mouth and tied securely at the top, this produces a balloon effect with the graft in the centre.

Complete shade of some kind must be provided, the writer has found ordinary brown paper bags most effective.

Some six to eight weeks later the polythene bag is slashed to harden off the scion. A week later the polythene bag is completely removed, but shade is retained.

Depending on the growth of the scion, but before restriction is too obvious, the raffia tie needs to be removed and replaced with another tie using much less tension than when making the original tie.

Shade is removed preferably during cloudy weather some 10 to 14 weeks after grafting, the final raffia tie is removed as soon as restriction is observed.

With this technique when grafting *P. radiata* or *P. patula* using stock and scion of the same species, over 95 per cent successful unions are often achieved.

Interspecific Grafts

Scion material received for seed orchard purposes from outside East Africa has to pass through quarantine at the East African Quarantine Station, Muguga, so that a common stock on which all *Pinus* species could be grafted is obviously desirable. To this end the writer has grafted *Pinus oocarpa, P. ponderosa, P. khasya, P. canariensis, P. montezumae, P. sabiniana, P. elliottii* and *P. echinata* all on *P. radiata* stocks using the technique described. Successful unions have been obtained in all cases. A similar number of species were also successfully grafted on *P. patula* stock, however, subsequent scion growth on *P. patula* stock is not so vigorous as when using *P. radiata* as stock.

Other interesting grafts made are *Metasequoia glyptostroboides* on *Cryptomeria japonica* stock and *Agathia robusta* on *Araucaria bidwillii* stock.

The accompanying photographs show the graft union and the amount of scion growth one year after grafting *P. radiata* stock and scion.

ACKNOWLEDGEMENT

The photographs are by D. Whitfield, East Africa High Commission.

THE EFFECT OF FUNGICIDES FOR THE CONTROL OF BLACK STEM RUST IN WHEAT ON THE GERMINATION OF THE RESULTING GRAIN

By R. J. Jones, District Agricultural Office, Ol'Joro Orok, Kenya

(*Received for publication on 13th December, 1960*)

An earlier paper [1] described two aerial-spraying trials for the control of black stem rust in wheat (*Puccinia graminis var. tritici*), using fungicides applied in low volumes of water per acre. It was concluded that both Zineb (zinc dithiocarbamate) and 0-3818-B (a mixture of the nickel and zinc salts of ethylene bisdithiocarbamate) were effective to some degree in controlling attacks of *P. graminis var. tritici*. It was also pointed out that the spraying of wheat crops with the fungicide O-3818-B might become a practical proposition to the farmer. The effect of spraying wheat crops on the germination of the resulting grain would then be of considerable importance.

It has been shown by Sempio [2] that wheat plants can take up nickel ions and by Wang *et al.* [3] and Peturson *et al.* [4] that nickel ions can be phytotoxic in high concentration.

The opportunity was taken to test the effects of spraying on samples of grain obtained from the rust control trials mentioned above to see whether any reduction in the germination percentage of the grain actually occurred.

EXPERIMENTAL

1. Random samples of grain from sprayed and unsprayed plots of Florence Aurore wheat were taken and from these samples 100 grains were taken at random and included in a randomized block layout of five replications of 20 grains from each treatment. The grains were placed on "Cestra" dairy filter pads inside glazed earthenware dishes. The grains were covered with another filter pad and the pads sprayed with water. The pads were kept moist throughout the test period by sprinkling water on the pads daily.

Germination counts were taken at 48, 72, 96 and 120 hours after the commencement of the test.

2. Tests similar to the above were also carried out on random samples of grain from the three wheat varieties in the Zineb trial of 1957. The grains had been stored in polythene bags since harvest at ordinary room temperatures. Random samples from the control plots and the plots receiving the heaviest spray rates were chosen for comparison.

Germination in both experiments took place at normal room temperatures.

RESULTS

A summary of the relevant data is given in Table 1.

TABLE I

Variety	Treatment	Date of Harvest	Date of Test	% GERMINATION AFTER:			
				48 hours	72 hours	96 hours	120 hours
Florence Aurore	3 sprays of 2 lb./acre of 0–3818–B	11–3–60	28–3–60	91	99	99	99
	Control	11–3–60	28–3–60	90	99	99	99
H.462	6 sprays of 2 lb./acre Zineb	23–2–59	2–4–60	72	96	97	97
	Control	23–2–59	2–4–60	84	94	97	97
339	5 sprays of 2 lb./acre ..	18–3–59	2–4–60	88	97	99	99
	Control	18–3–59	2–4–60	92	94	96	96
294B	5 sprays of 2 lb./acre Zineb	20–3–59	2–4–60	65	71	85	86
	Control	20–3–59	2–4–60	67	73	82	87

With the exception of 294B all varieties germinated extremely well and very quickly. The variety 294B was slow to germinate and even after five days only 87 per cent of the grains had germinated. This may have been due to the heavy rust attack on the parent plants resulting in small shrivelled grains.

Storage of the grain in polythene bags for 12 months appears to have had no ill effects on the germination of the grain.

Control plots invariably germinated first, but this initial advantage was lost by the end of the five-day test period. There were no visible differences between plants resulting from sprayed grain when compared with their unsprayed controls.

In no instance was there a significant difference in germination between treatments.

SUMMARY AND CONCLUSIONS

Grains of Florence Aurore wheat from plots which had been sprayed with the fungicide O-3818-B for the control of black stem rust were compared with grains from unsprayed controls in a germination experiment.

Grains from three other varieties—H.462, 339 and 294B—which had been sprayed with Zineb for rust control in 1958 were also compared with grain from control plots in similar germination experiments.

Germination results revealed that grain from control plots invariably germinated first but after five days there were no significant differences between treatments for any variety. The variety 294B was slower to germinate than the others and the germination percentage after five days was some 10 per cent lower.

It is concluded that spraying with Zineb and O-3818-B for the control of stem rust in wheat, at the rates used in the trials, had no deleterious effect on the germination of the resultant grain.

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REVIEW

THE BALKAN LAKE OHRID AND ITS LIVING WORLD. Monographiae Biologicae, Vol. IX, by Sinisa Stankovic, Published by Uitgeverij Dr. W. Junk, Den Haag, 1960, pp. 357 (101 figs.). Price *F.* 35.

Lake Ohrid is situated on the border between Yugoslavia and Albania and is of especial interest to biologists because of the very high proportion of endemic plant and animal species that are found in and around it. Professor Stankovic's book is basically a summary of all that it known scientifically about Lake Ohrid (the bibliography contains some 459 references). He also takes the opportunity to point out how much is not known and where further research can be undertaken.

The main emphasis of the book, however, is on the very high degree of endemism found in the flora and fauna of the lake (e.g. 10 out of 17 species of fish are endemics as are nine-tenths of the Gastropods and two-thirds of the Ostracods. 13 species of diatoms are present which are only known in fossil form from other parts). This mass of endemic species is probably associated with the great age of Lake Ohrid (upper Pliocene) and its ecological isolation for it lies in a Karstic depression with a very small drainage area.

The book is easy to read, but unfortunately tends to be somewhat repetitive in certain parts due to the way in which the contents have been organized. Part of this book seems directed towards taxonomists and part towards ecologists whose basic approach is not strictly taxonomic. This splitting of aims has resulted in a considerable loss of the book's impact. It is regrettable also that the standard of reproduction of the photographs is so poor and that so many typographical errors occur, particularly in the later sections.

The book is of particular interest to East African biologists in that Lake Ohrid is one of the great inland waters whose endemic flora and fauna can be compared with Lake Baikal in Siberia and Lake Tanganyika. It is hoped, therefore, that this volume will lead to a similar summary of scientific knowledge from those engaged in research work on Lake Tanganyika.

Professor Stankovic's book can be recommended to all those interested in hydrobiological research, and the ecological and taxonomic problems associated with speciation. We are fortunate indeed that this work was published in the English language.

M.D.G.

NEMATOCERUS **sp. (nr.** brevicornis **Hust)—A PEST OF CEREALS IN KENYA**

I—THE BIONOMICS AND CONTROL OF THE ADULT AND LARVA

By J. A. Bullock, Entomologist, Dept. of Agriculture, Kenya

(*Received for publication on 13th December, 1960*)

Weevils of the genus *Nematocerus* (Col. Curculionidae) have been well-known defoliators of a wide range of plants for many years and Le Pelley [1] records them as damaging wheat, flax, maize, beans, wattle, and pasture grasses, whilst the author has recorded them also on barley, oats, potatoes, pyrethrum* and *Lolium perenne* leys as well as a number of endemic grasses and herbs. Although there were heavy outbreaks throughout much of the Rift Valley Province in 1960 (*see* map), in most years only one or two outbreaks on isolated fields have been recorded and consequently the weevil has not been regarded as a major pest of cereals. The only study on methods of control is that of Elmer and Smith [2] on *N. perditor* on wattle and no study of the life cycle has been made.

Apart from an infestation suspectedly due to larvae of *Nematocerus* (Walker, 1953, *in litt.*), the larvae had never been recorded attacking crops until May-June, 1957, when P. T. Walker (*in litt.*) and the author simultaneously found large numbers attacking maize at Endebess and Londiani respectively. In August, a field of wheat at Eldoret was badly damaged and in November some 400 acres of wheat and barley at Naro Moru were very heavily attacked. Subsequently, the infestation in the Naro Moru area spread to include Moyo Ridge and in 1960 4,000 acres were estimated to be affected in the two areas. Elsewhere, the infestations have not increased; those at Londiani and Eldoret have disappeared whilst that at Endebess has continued but has remained confined to part of a single farm. In addition, an infestation on a single farm in the Aberdares has persisted for two years, and larvae were found associated with attacks by adults in several other areas in 1960.

Although no records exist, the larvae have probably caused damage in the past and have either never been noticed or have been incorrectly identified. Thus both P. T. Walker's and my own first diagnoses of the pest were due to our being fortuitously on the farms involved. Also, in attacks attributed entirely to adults, the author has found larval populations and occasionally fairly heavy damage by the larvae. Finally, the layman often confuses Curculionid and Scarabaeid larvae, and the infestation investigated by Walker had previously been identified as *Schizonycha* sp. larvae by such a person.

The following account is of work done by the author on the larvae in 1957 and 1958, and on the adults between 1956 and 1960.

Symptoms of Attack

The adults are defoliators, eating irregular pieces from the edges of leaves and, in heavy infestations, consuming all the green material available. In young cereals, they will also eat through the stem.

The larvae are subterranean and attack young cereals in the region between the grain and the surface, causing death by eating through the stem. They will also enter the seed and hollow it out causing an initial patchy germination. On older cereals, the larvae are mainly root feeders, and cause little apparent damage except that occasionally they attack the shoot below the surface, producing death of the central leaves and the growing point. It is however probable that large populations have a hidden effect on yield through such a root attack.

Identity and Descriptions

The genus presents taxonomic difficulties and no accurate determination of species has been made. Of the identified specimens in the collections of the Coryndon Museum and the Scott Agricultural Laboratories the species appears to be close to, if not conspecific with, *N. brevicornis* Hust., *Adult* (Fig. 1). The weevil is 7-9 mm. long and black with a bronze reflection. The scape is rather shorter than the remaining antennal joints including the three-jointed club. The head and pronotum are glabrous but the latter is distinctly rugose. The elytra are rather expanded in the female and almost straight sided in the male; the striae are strongly punctate basally, becoming mere depressions apically and laterally, whilst the interstices are faintly raised.

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* On pyrethrum the petals are eaten and the leaf petiole chewed, the latter causing death of the whole leaf. However, in the pyrethrum field that I visited, large numbers of dead adults were found around the base of the plants, suggesting that the plants were toxic to them.

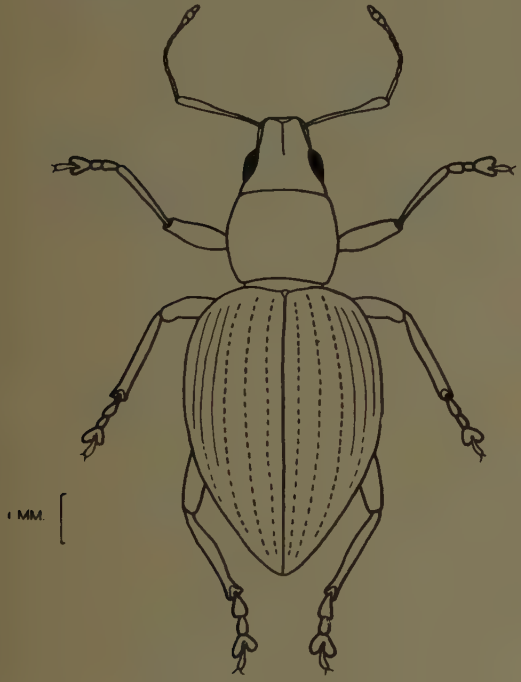

Fig. 1.—Adult female

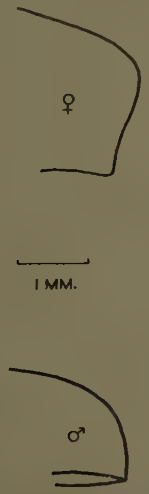

Fig. 1a.—Lateral view of the apex of the left elytron and abdomen in the female and male

The sexes are most readily distinguished by the shape of the apex of the elytra in lateral view. In the female, the apex is acutely angled whilst in the male it is only right angled. (Fig. 1a). The aedeagus is typically curculionid and the median lobe is strongly produced apically (Fig. 1b).

Larva (Fig. 2).—The larva is a white, apodous, C-shaped grub with a lightly tanned head. The length at hatching is 1 mm. and

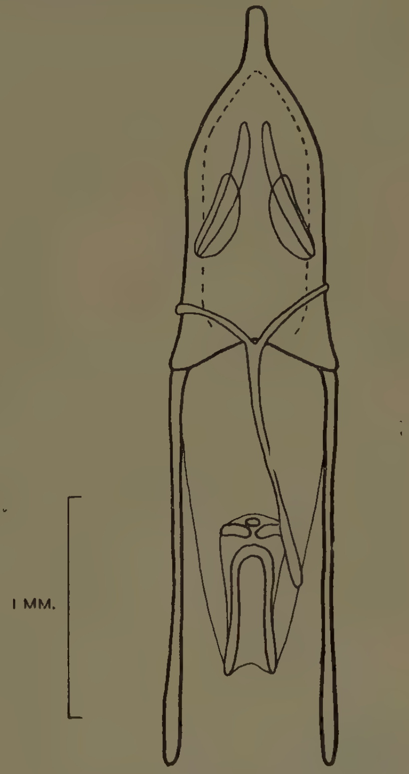

Fig. 1b.—Ventral view of the aedeagus (excluding the *spiculum gastrale*)

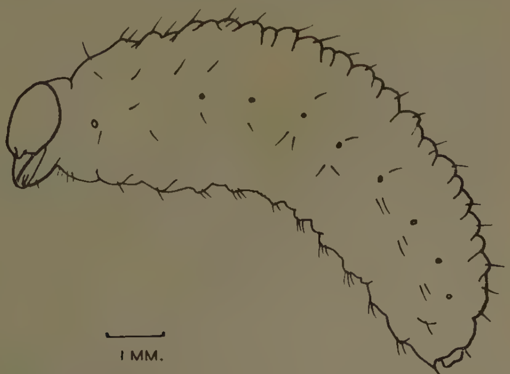

Fig. 2.—The fully grown larva (slightly extended)

when full grown about 8 mm. A transverse row of backward-pointing setae is present on the ventrum of each segment and these rows of setae are used in locomotion; a few other setae occur around the spiracles and on the dorsa.

Life Cycle

The ova are laid on vegetation in batches up to 54 in number with a mean of 19 to 21. The most frequent site is the leaves of Gramineae, but ova have also been found on the petals of pyrethrum (*Chrysanthemum cinerariaefolium*). The Gramineae on which oviposition has been recorded are *Pennisetum clandestinum, Lolium* hybrid H.1, *Eragrostis* sp., Digitaria scalarum, *Digitaria* sp., *Hordeum vulgare* and *Avena sativa.* The ova are laid on the upper surface of a folded leaf, the fold being made by the female transversely straddling the leaf on the underside, and forcing the upper part of the leaf over and down, until it meets the lower portion. At the same time, the body of the weevil moves backwards, and the apex of the abdomen comes to lie between the opposed surfaces. A layer of adhesive is secreted from the abdomen and deposited on the far side of the leaf, the eggs laid, and the pocket completely sealed with a further layer of adhesive (Fig. 3 and 4). Normally, only one batch is laid on a leaf, but in some cases a second and even a third hatch is laid, the first pocket being included in the second fold and both in the third. The ova in the pockets are at different stages of development and are presumably the progeny of two or three females.

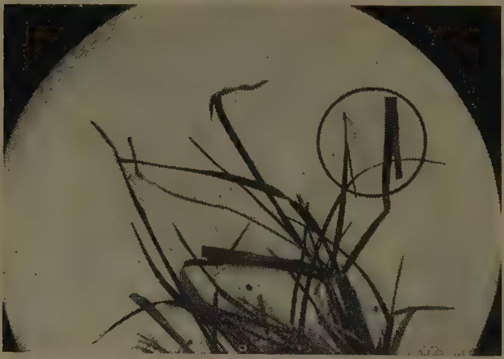

Fig. 3.—Tussock of grass with leaves folded by *Nematocerus* for oviposition. The ring contains two such folds

In the laboratory, oviposition has also been recorded on the soil surface but this is almost certainly the result of lack of sufficient material for both food and oviposition, or to oviposition on leaves which are subsequently eaten so that the ova fall to the ground. The occurrence of so elaborate a laying habit in nature renders it unlikely that a simple alternative occurs under normal conditions.

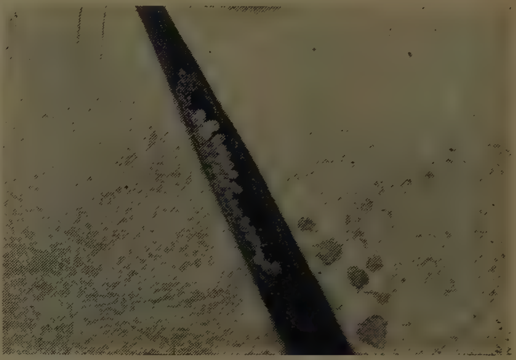

Fig. 4.—A leaf fold opened to show the ova and the surrounding band of adhesive

The egg hatches after 12 to 15 days, the larva chewing its way through the chorion and becoming free in the pocket. It then cuts a small circular hole in the lamina of the leaf and emerges. This exit hole is used by several larvae and usually one one to five holes are cut for all the larvae to emerge.

After quitting the pocket, the larvae move around on the leaf surface and eventually fall to the ground where they quickly burrow into the soil. Once in the soil, they are very resistant to drought conditions, and healthy first instar larvae have been recovered from soil in pots after several weeks without watering. Little is known of the subsequent development of the larvae but it has been observed that the larvae move down to avoid drought and will go to depths of over a foot. M. M. Katala (personal communication) reports finding one larva at a depth of over 3 ft. in light volcanic soil. It is probable that the larvae feed on the roots and on debris until the soil dries out and then move down and become quiescent. They ascend when the soil is thoroughly wetted again and continue feeding until mature, when they pupate in an earth cell in the top two inches of soil. The pupal stage lasts about two weeks, and the newly emerged adult rests for a few hours in the cell before making its way to the surface. The adults feed at night and during dull periods of the day, and avoid direct sunlight by sheltering under clods. They are flightless and therefore incapable of active wide dispersion. Adult weevils have been found in bags of seed wheat and it is possible that this could provide a means of mechanical dispersal. The ovaries are undeveloped at emergence, and oviposition does not take place until at least a week after emergence. Adults have lived for seven weeks in the insectary, but in the field the period of survival is shorter.

Parasites and Predators

The ova are attacked by a Chalcidoid larva which can eliminate many of the eggs in the batch. The ovum is laid on the host eggs, usually at the upper end of the pocket near the fold and it is assumed that the ovipositor is inserted through the adhesive since no hole can be found in the lamina. Usually one larva is found but occasionally two larvae of different ages are present. This is less frequent than would be expected if selection of egg masses was purely random and in two series of egg masses the following figures were obtained (Table I).

TABLE I

(Number of Chalcidoid larvae in two series of egg masses)

No. of egg masses	Percent attacked	No. containing 1 Chalcidoid larva	No. containing 2 Chalcidoid larvae	*Expected No. containing 2 had selection been random
135	31·85	42	1	13·7 $\chi^2 = 14{\cdot}09$ $P < 0{\cdot}005$
88	35·23	28	3	10·9 $\chi^2 = 6{\cdot}54$ $P < 0{\cdot}025$ $> 0{\cdot}010$

$$\text{*Expected No.} = \frac{\textit{Total No. infested}^2}{\text{No. of egg masses available.}}$$

It is probable that the wasp shows some selective power, but since removal of the egg masses protected them from further infestation, this evidence is not conclusive. The percentage attack is also shown, but this again is incomplete because of collection. However, these figures are probably fairly close, since the period during which attacks take place must be severely limited.

Observations on the life cycle showed a 2-3 day period from oviposition to hatching, and since pupation occurs at about the same time that surviving larvae emerge, the larval period lasts at most 12 days. The recorded pupal period is 7-10 days.

The distribution of this ecto-parasite does not appear to coincide with that of *Nematocerus;* collections from Ol Joro Orok and North Kinangop giving values of 33 per cent whilst a similar series from Naro Moru produced no specimens.

Three other species of hymenoptera have been recorded from egg masses, of which at least one is an egg parasite.

In addition, a red mite has been recorded feeding on the eggs in a few masses.

No information is available on predation in the larvae, except that a large Dipteran larva was found feeding on a live larva and several similar larvae have since been recorded in samples of soil.

Distribution

Reference to the map shows that the insect occurs throughout the province but all recorded infestations have been in areas which may be classified as highland grassland on fairly light loam soils. In no case has an infestation occurred on heavy clay soils and this is almost certainly a result of such soils compacting on drying thereby restricting movement of larvae in the ground and preventing entry of young larvae. The insects can probably exist in small numbers under such conditions but only where the soil texture has been changed by addition of manure, e.g. in old *manyattas,* can they cause damage.

Control of the Adult

The previously described methods of control have been poison baits, Elmer and Smith [2] describing one of cob meal, molasses and gamma BHC whilst Graham [3] recommended one of gamma BHC and chopped green maize for *Systates,* in which genus *Nematocerus* was included by the author. Since baits present difficulties in adequate dispersion over an area of crop, the use of a spray was considered advisable, and a preliminary test with D.D.T. showed that very good results could be obtained. Subsequent results reported by farmers, and confirmed by the author where possible, showed that D.D.T. as a spray or dust gave very good control (Table II). In addition, the gamma BHC bait of Elmer and Smith was found to be effective although the users complained of difficulty in formulation as well as in obtaining a good distribution over the field.

TABLE II.—CONTROL OF ADULTS WITH INSECTICIDES

Insecticide	Formulation	Quantity of active insecticide per acre (oz.)	Method of Application	Result
DDT	25% EC[2]	15	Tractor mounted sprayer	Good[1].
DDT	25% E.C.	15	Tractor mounted sprayer	Good.
DDT	25% E.C.	15	Tractor mounted sprayer	Good.
DDT	25% E.C.	15	Tractor mounted sprayer	Good.
DDT	25% E.C.	15	Tractor mounted sprayer	Good.
DDT	25% E.C.[2]	15	Knapsack sprayer	Good.
DDT	25% E.C.	15	Aerial spray	Good.
DDT	2% Dust	13	Hand dusting with coarse bags.[3]	Good.
DDT	2% Dust	13	Hand dusting with coarse bags.	Good.
DDT	2% Dust	5	Hand dusting with coarse bags.	Good.
DDT	2% Dust	10	Knapsack dusters }[4]	Good.
BHC	Poison bait on bran substrate.	0·66 gamma	Broadcast by hand	
BHC	Poison bait on bran substrate.	0·66 gamma	Broadcast by hand	Partial Control.
BHC	Poison bait on bran substrate.	0·66 gamma	Broadcast by hand	Good.
BHC	Poison bait on a pyrethrum marc substrate.[5]	0·66 gamma	Broadcast by hand	Good.
Dieldrin	18% E.C.	7·2	Tractor mounted sprayer	Ineffective.

1. Results reported on by farmers had to be qualitative. "Good" signified "Few, if any, live adults present and complete cessation of damage;" "partial control," "numbers of dead weevils found but a proportion remained and caused damage."
2. E.C. = Emulsifiable concentrate.
3. The dust was placed in coarse-woven bags and these were shaken over the crop.
4. The two methods were combined to save wheat trials at the Plant Breeding Station, Njoro.
5. Pyrethrum marc is the residual ground flowers obtained after extraction of pyrethrins. It contains 0·08–0·1% pyrethrins.

Before the results quoted in Table II became available, it was thought possible that spray and dust applications might fail because many weevils would not be directly hit by the insecticide since they would be hiding under clods. An experiment was set up to test whether a residual action on the plants was effective. Maize plants were treated in the field and six hours later were placed in cages containing five or six healthy, untreated weevils. The insects were examined 24 hours later and classified as living, sick or dead; sick signified showing some life but disorientated and incapacitated. The results (Table III) show that D.D.T. spray was the most effective, whilst D.D.T. dust and gamma BHC spray were less efficient but would probably be satisfactory in the field since all sick weevils could be expected to die through dehydration.

TABLE III.—EFFECT OF RESIDUAL DEPOSITS ON ADULT WEEVILS

Insecticide	Formulation	Rate of active insecticide per acre (oz.)	Result after 24 hours (6 replicates)			
			H.	*S.*	*D.*	*Total Affected*
DDT	Water miscible concentrate	15	3	9	22	31
DDT	2% Dust	13	13	14	6	20
gamma BHC	Wettable powder	4	12	10	9	19
Dieldrin	Water miscible concentrate	7·2	29	0	0	0
Sevin	Wettable powder	8	24	1	2	3
Control	—	—	30	0	1	1
		Least Significant Difference			5% —	9·0
					1% —	12·2

H = Healthy; S = Sick; D = Dead.

Control of the Larvae

1. *Estimation of Larval Populations.*—Populations were assessed by means of a coarse soil washing technique similar to that used for counting wireworms in Britain [4] which was sufficient to extract the larger larvae and all pupae. Four-inch cores of soil were collected into tins, water was added and the samples were placed in a refrigerator and frozen solid for at least 24 hours. They were removed and allowed to thaw, and then washed through two sieves, an upper coarse sieve of ¼ in. mesh which retained stones and pieces of debris and a lower fine sieve of mosquito gauze, which retained the majority of the larvae and the pupae. The fine sieve was then placed in a brine bath (S.G.1.18 – 1.2) in which the larvae rose to float on the surface and could be picked off.

Populations determined in this way varied between a half and two million larvae per acre. (The latter population had completely eliminated a stand of barley undersown to *Setaria sphacelata*.)

2. *Control by Chemicals*: (*a*) *Pre-treatment.*—A number of observation trials with dry seed dressings were planted and four trials sustained an attack and were assessed by the quality of stand. In all cases, the soil was examined to ascertain whether the observed damage was due to *Nematocerus* larvae and in one experiment where seed was resown on an attacked field each treatment was assessed for larval population.

The results (Table IV) show that no seed dressing has given good control, although Dieldrin, Heptachlor and Thiometon apparently gave a slightly improved stand on one occasion.

In addition, observations on farmers' crops confirmed that Aldrin at 4.8 oz. and gamma BHC at 2 oz., each per 100 lb. seed, had no effect, whilst an infestation on a seed dressing trial against *Hylemyia arambourgi* showed that Dieldrin at 5 oz. and 3.5 oz. actual per 100 lb. seed had failed to reduce populations. A claim by one grower that a dressing of lead arsenate was effective could not be accepted since a heavy population of larvae was present when the site was examined. There was little damage showing on the treated plants except in one area, but this was also true of "volunteer" plants, and the lack of damage was attributable to the crop having been planted before the rains and having grown sufficiently well to support an attack on the roots without apparent ill effects.

An indication of the tolerance of Aldrin shown by the larvae was obtained when larvae were placed in (1) 1 per cent Aldrin in water solution for 24 hours and (2) 1 per cent w/w Aldrin in soil for a similar period. In both, the larvae were unaffected by the chemical whilst a 1 per cent Thiometon/soil mixture gave a complete kill in the same period.

Gamma BHC was also tested as a mixture with fertilizer, to give 4 oz. actual gamma BHC per acre applied in the row but this again failed to provide any control.

(*b*) *Post Attack Treatments.* Spray applications were tested on two occasions on established attacks and these were assessed by counts of the larval populations before and two weeks after treatment. In no case did an insecticide exert any satisfactory control (Table V), the apparent partial control with Dieldrin on one occasion being due to sampling error.

TABLE IV.—EFFECT OF SEED DRESSINGS IN CONTROLLING LARVAL INFESTATIONS

Insecticide	Active Insecticide per 100 lb. Seed	Resultant Stand—Visual Assessment
	oz.	
Dieldrin	6	Poor (100)*
Dieldrin	5	Thin and patchy.
Dieldrin	2	Very poor.
Aldrin	2	Very poor.
gamma BHC ..	2	Poor (100)*
gamma BHC ..	2	Very poor.
Heptachlor ..	4	Thinned and patchy.
Thiometon ..	5	Thinned and patchy.
Endrin	5	Poor.
Lead arsenate ..	5	Very poor.
Controls.. ..	—	Very poor.

*Bracketed figures indicate larval population as a percentage of that of the untreated control.

TABLE V.—EFFECT OF SURFACE APPLICATIONS ON LARVAL POPULATIONS

Treatment and Rate	Percent reduction during period of experiment	Percent reduction on the untreated plot during period of experiment
Dieldrin at 9·2 oz. per acre..	41·0	43·0
Endrin at 6·0 oz. per acre..	33·0	43·0
Chlordane at 40·0 oz. per acre	42·0	43·0
Dieldrin at 7·4 oz. per acre and harrowed in	33·3	Nil
Aldrin at 12·8 oz. per acre and harrowed in	Nil	Nil
Thiometon at 10 oz. per acre	Nil	Nil

3. *Control by Cultural Techniques.*—In the Naro Moru and Moyo Ridge areas, due to there being two rainy seasons, an increasing number of farmers had been attracted by the possibility of growing two crops a year and in many cases this practice was carried to the extreme of taking two crops off the same field in one year. Although it was not possible to conduct controlled experiments on the effects of this practice, observations suggested that a reversion to single cropping with a consequent fallow during part of the year would greatly assist in reducing the incidence of larval infestations. There were also indications that larvae could exist in large numbers without apparently affecting the crop if it was planted two or three weeks prior to the onset of the rains.

(*a*) *Effect of Fallowing.*—Observations were made on two adjacent fields during the three seasons November, 1957, April, 1958, and November, 1958. The fields were separated by a 5 yd. grass strip and in April, 1958, were planted with the same wheat cultivar, H.462, at the same time. The progress of the infestation (Table VI) in these two fields showed that after a disastrous attack, causing an enforced fallow, the infestation disappeared. This was the result of the migration of adults from bare ground in search of food and sites for oviposition.

TABLE VI

Season	Field 1	Field 2 (part (*a*))	Field 2 (part (*b*))
Nov. 1957	Heavy attack	Light attack	Very light attack
Result	Enforced fallow	Good crop	Good crop
April 1958	No attack	Heavy attack	Light attack
Result	Good crop	Enforced fallow	Medium crop
Nov. 1958	No record No attack ?	No attack	Heavy attack
Result	?	Good crop	Enforced fallow in part Poor crop elsewhere

It is also noteworthy that the infestations on both parts of field 2 showed a build-up so that it would have been possible to impose a fallow as a control measure without the expense of planting in April, 1958, and November, 1958, in the respective parts.

(*b*) *Effect of Early Planting.*—On several occasions it was observed that fields which had been planted two or three weeks prior to the rains, and with sufficient moisture to promote germination, were able to support large populations of larvae without apparent deleterious effects. Since larvae cannot be found in the top few inches of soil until after the onset of the rains, it is probable that these plants were sufficiently well-grown to offer an adequate food supply to the larvae without their attacking the stem.

4. *The Effect of Controlling Adults.*—The adults are more susceptible to chemical control than are the larvae, and since there is a considerable period between emergence and oviposition, the application of insecticides against the adults appears to offer an effective means of controlling potential infestations of larvae. This was most noticeable at the Government Experimental Farm, Ol Joro Orok, where only very light oviposition could be found on sprayed fields whilst heavy oviposition had taken place on an untreated grass ley and a portion of an unsprayed field of oats.

Discussion

Two factors may have affected the occurence of larvae in numbers sufficient to cause damage. First, the practice of "double-cropping" in the Naro Moru and Moyo Ridge areas, or the climatic conditions suitable to this practice, appear to have provided suitable conditions for the larvae. This is supported by the important observation that fallowing is deleterious to the pest. Secondly, since the larvae are tolerant of insecticides in the quantities used as seed dressings, the growing popularity of this type of chemical treatment may have assisted the larvae by eliminating a hypothetical parasite or predator.

The absence of the Hymenopterous ectoparasite of the eggs from the Naro Moru region offers a third alternative factor but further research on this facet is required.

Although it has been postulated that the outbreak is the result of an induced resistance to insecticides, there is no supporting evidence to this effect. The widespread occurrence of the pest within a short period and showing a high tolerance of the larvae to all the normal insecticidal treatments argues in favour of a natural resistance (tolerance). It is most improbable that an induced resistance could have either become so widespread so rapidly in a slow dispersing insect, or arisen at several foci independently.

The results with insecticidal seed treatments suggest that this method of control cannot be regarded as likely to provide an answer unless a more efficient insecticide can be found. The rates of application tested were the maximum dosages possible with the formulations available, and any attempted increase on this rate would not adhere to the seed. This difficulty might be overcome if formulations with a higher concentration of insecticide became available—but this is unlikely because of the technical difficulties of formulation—or if liquid seed dressings were used.

An alternative method is the application of insecticide either with the fertilizer or broadcast, when the quantity is only limited by cost and by the effect on the plants and the soil fauna. It is unlikely that such a method will prove popular since a farmer will be unwilling to make an expensive application to a number of fields in the expectation that one or two of them will be attacked, especially in crops where the average profit margin is less than Sh. 50 per acre. It follows that a method of forecasting an attack would have to be developed so that treatments need only be applied to potentially infested fields. This is impractical. The examination of the soil for larvae prior to planting would necessitate sampling to depths of at least 18 in. and then sieving through fine sieves and further separation of the larvae from debris—a quite impossible task to perform on a large scale in this country. An alternative method of forecasting would be the examination of fields for oviposition on the leaves in the previous season, but although this might be practicable, it would certainly be easier and more economic to watch for the adults and eliminate these when they occur.

The prospect of control by cultural techniques is more hopeful in the double cropping areas since it is certain that a measure of control will be obtained by the avoidance of double cropping and the imposition of a fallow for part of the year. This would be assisted by disc-harrowing the fallow to remove weed growth and open the soil. Early planting, which would be facilitated by the fallow, would help to reduce damage although not itself affecting the infestation in the field.

Finally, the elimination of adults by the application of D.D.T. or the use of BHC baits should be regarded as of prime importance in all areas where the larvae cause damage. If this is done properly, there is no reason why the larvae should ever appear in sufficient numbers to cause damage. Also, when infestations are noticed in rough grazing they should be either eliminated, or prevented from entering a crop by poison baiting at the edges of the field.

Summary

A history of the occurrence of adults and larvae of *Nematocerus* sp. (nr. *brevicornis*) is given together with a description of the symptoms of attack.

The adult and larva are described and figured, and observations on the life cycle discussed.

D.D.T. sprays and dusts as well as BHC baits are shown to be effective on a field scale in the control of adults.

Chemical control of the larvae with normal seed dressings and surface sprays is shown to be ineffective.

Cultural control of the larvae by avoidance of double-cropping and by dry planting is considered to have possibilities in the Naro Moru and Moyo Ridge areas.

In other areas, it is suggested that the only practical control is the chemical control of the adults, possibly assisted by dry planting.

The origin of the outbreaks is discussed and attributed to the cultural usage in the double cropping areas, whilst the other minor outbreaks have possibly always occurred and not been correctly diagnosed. In all areas, the use of seed dressings of which the larvae are tolerant may have aggravated the position.

In the field of larval control, the portents for a satisfactory chemical control are not encouraging since the type of insecticide applications envisaged will probably be uneconomic. Cultural control where applicable and chemical control of adults appear far more promising.

Acknowledgements.—I have to thank Messrs. Barrat, Kuhle, Petersen, Prettejohn, Norman and Thrane, and Strong for assistance with experiments on their land, and the many other farmers who have made observations for me. I am most grateful to my colleagues of the Department of Agriculture, Kenya, for their willing assistance and especially Mr. R. J. Jones for his assistance with work at Naro Moru, Mr. P. Moberly who performed one trial at Kitale, Mr. R. E. Eggleston for his observations on oviposition, and Mr. A. W. Peers for his general assistance in the Ol Joro Orok-Mount Kenya area.

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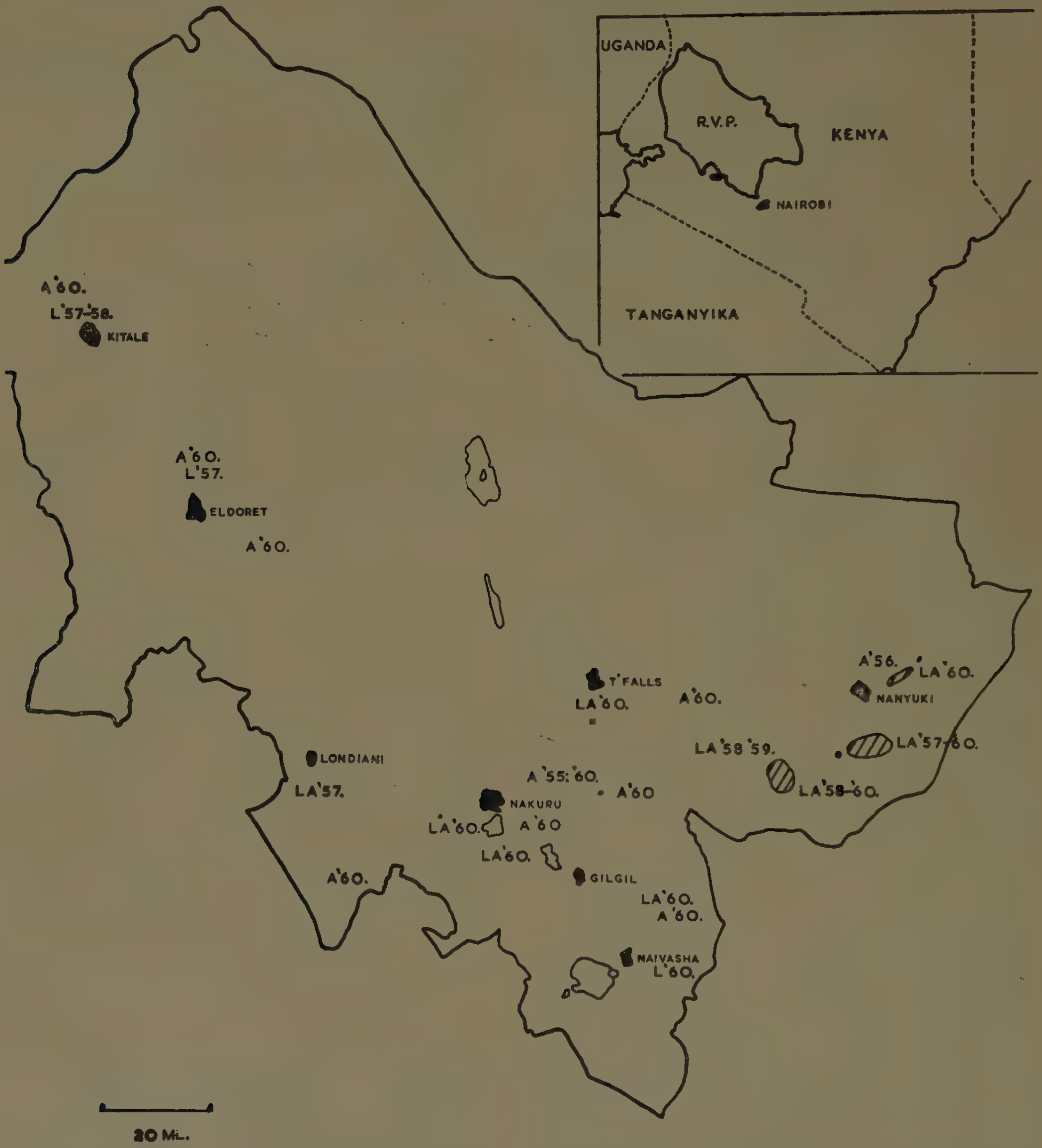


Map of the Rift Valley Province showing recorded infestations of adult (A) and larval (L) Nematocerus and the years in which the outbreaks were recorded. Shaded areas indicate that outbreaks were spread over several farms, otherwise records only refer to single farms. The inset map shows the location of the province in relation to Kenya and surrounding countries

THE INSECT PESTS OF AGRICULTURE IN THE COAST PROVINCE OF KENYA

IV—COCONUT

By **P. E. Wheatley, Entomologist, Department of Agriculture, Kenya**

(*Received for publication on 22nd June, 1960*)

The coconut palm is near its economic limit on the Kenya Coast and only in the wetter areas is it a profitable crop on a plantation scale. However, it can be said that it is an economic crop under peasant conditions over a wide area, and thus it is of very great importance to the general economy of the Coast.

The two main pests of coconut in Kenya, Rhinoceros Beetle (*Oryctes*) and the Coreid Bug (*Pseudotheraptus*), cause considerable losses to the coconut industry, but neither pest produces spectacular damage symptoms and their importance is normally not fully recognized or understood. It is therefore important that propaganda concerning measures for their control should be accompanied by a full explanation of the life histories of the pest and the nature and importance of their damage to the crop. It is suggested that the specific pest control measures outlined below should be combined with general crop improvement measures and seed-nut selection work, in particular the improvement of soil moisture availability by elimination of weed growth. This policy has been in use in Kenya for some years now, but care must be taken to prevent any loss of momentum in the campaign once the initial impetus of the first few years has worn off.

MAJOR PESTS

RHINOCEROS BEETLE (*Oryctes monoceros*)

The adult is a large black shiny beetle $1\frac{1}{2}$ in. long, with a rhinoceros-type frontal horn which is well developed in the male but very short in the female. The larva is a wrinkled, fleshy white grub with a brown head, and may reach a length of 3 in.

Life History

The eggs are oval, dirty white, $\frac{1}{8}$ in. long and are laid singly, usually in the rotting wood of dead coconut trunks, although they may be laid in heaps of decomposing vegetation or manure. The larvae hatch after 10 to 12 days and feed on the rotting wood or manure for about two months by which time they are fully grown and pupate. Pupation lasts three weeks and the adults, on emerging from the pupal cases, tuunel their way out of the breeding site to the open. They are strong fliers, but are not often seen as they only fly at night.

A large blue-black wasp with orange antennae, *Scolia ruficornis*, parasitises a very small proportion of the larvae. A large Assassin Bug, *Platymerus rhadamanthus*, preys on the adults, but neither of these insects causes any appreciable reduction in the Rhinoceros Beetle population.

Damage

Damage to the coconut is done by the adult beetles who feed on the "cabbage".

The "cabbage" is the single vegetative bud of the coconut and consist of the tightly rolled embyro leaves which surround the apical meristem of the growing point. The growing point gives rise to all new growth of the palm and if damaged leads to the death of the palm. The adult Rhinoceros Beetle chews its way into the cabbage leaving a tunnel of approximately 1 in. diameter. In most cases the beetle leaves the palm before the tunnelling reaches the growing point and damage is limited to the developing leaves which, when they eventually unfurl, show characteristic V notches or holes arranged in a geometrical pattern. However, in some cases the beetle tunnels right to the centre of the cabbage and destroys the growing point, causing the death of the tree and it is in this manner that Rhinoceros Beetle does its greatest amount of damage.

Crop losses resulting from attack by Rhinocerous Beetle are difficult to assess. At Gazi, where attack is only moderately severe, deaths of bearing palms from Rhinoceros Beetle average 2 per cent per year, and assuming replanting takes place immediately this represents an average loss of bearing capacity of approximately 15 per cent, for the replants take seven or eight years to come into bearing. Losses in some areas of the Coast are undoubtedly very much higher than this. In addition a further but lesser reduction in bearing capacity will occur due to leaf damage on palms that are attacked but not killed. This reduction is approximately proportional to the loss of leaf area.

The degree of Rhinoceros Beetle damage may vary from one plantation to the next. Isolated palms and palms of irregular heights at irregular spacings are more prone to attack than closely planted palms of the same age forming a fairly continuous canopy. The reasons for this are not fully understood but may be connected with the faculties of perception of this nocturnal beetle.

Control

It is both uneconomic and impracticable to spray the crowns of all coconuts at regular intervals to prevent attack by adult beetles. Neither is it practicable to treat only those palms that are attacked for in the majority of cases the beetle has done the damage and flown away before signs of attack are seen. Control is therefore based upon interrupting the life cycle of the pest by destroying all the sites where breeding can take place. Action along these lines must be taken by all coconut growers to reduce Rhinoceros Beetle populations, and legislation was passed (Coconut Preservation Ordinance, 1915) to enforce the destruction by all coconut growers of the breeding places of Rhinoceros Beetle. The legislation requires all growers to cut down and destroy dead coconut palms and to prevent accumulations of organic matter or manure which are likely to provide breeding places for the pest. In practice, it has been found that burning is the most satisfactory method of destroying coconut logs, and to facilitate drying out of the wood prior to burning, the logs should be cut into lengths of 5 or 6 ft. and then split once or twice longitudinally and stacked in a criss-cross manner. When felling a dead palm the trunk should be cut at a height of not more than 2 ft. from the ground, for stumps of this size soon become infested with ground nesting termites and are rendered unsuitable as a breeding site for Rhinoceros Beetle. Taller stumps, however, must be grubbed out and burnt.

As the life-cycle of Rhinoceros Beetle takes approximately three months, it is necessary to complete destruction of coconut logs within three months of the death of the palm. Similarly, accumulation of vegetable matter must not be allowed to remain for a period exceeding three months.

Other methods of control have been tried in other parts of the world. Trapping is not recommended for Kenya due to the expense and to the very close supervision which is required to ensure that the traps are regularly treated and are not left unattended to become dangerous breeding foci. Regular inspection of coconuts to find adult beetles tunnelling in the crowns has been tried. Although adults so found are easily extracted with a hooked springy wire and killed, the degree of control achieved was negligible. Biological control of Rhinoceros Beetle by other insects and by insect diseases is being actively studied by entomologists of the South Pacific Commission, but the method of control is unlikely to contribute much to the solution of this problem in Kenya though organisms already present in Kenya may well be of value to other parts of the world. Therefore control of the pest by enforcement of the Coconut Preservation Ordinance must continue. The effectiveness of the measures is sometimes queried by coconut growers. Such people should visit an area of coconuts at Changamwe, near Mombasa, where for administrative reasons the Ordinance has not been enforced during the last few years, and where Rhinoceros Beetle populations have increased to a high level. The resultant damage is spectacular.

COREID BUG OF COCONUTS (*Pseudotheraptus wayi*)

The adults are brown, $\frac{5}{8}$ in. long, with well developed wings. The nymphs are red-brown, brown or green-brown and wingless.

Life History

Eggs are laid singly in the crowns of coconut palms and hatch in seven or eight days. The nymphs crawl about the inflorescences feeding on the developing nuts, showing a preference for the young nutlets (vidaka) of up to 2 in. in length. They remain for their whole nymphal life in the crown of the palm. The fifth nymphal instar moults directly to the adult, there being no pupal stage. The adult is an active flier and moves about from one palm to another. After 8-11 days the adult female commences to lay eggs at the rate of three or four a day for a period of two months or longer before dying. These eggs may be parasitised by the endemic wasp *Ooencyrtus* sp. or by an unidentified egg parasite recently introduced to Kenya from Zanzibar.

Although coconut is the main host of *Pseudotheraptus*, cashew and mango can serve as alternative host plants during their fruiting season. Fruiting guava and some species of mangrove have also been recorded as alternative hosts of *Pseudotheraptus* in Zanzibar.

Damage

Nymphs and adults feed on developing nuts by piercing them through the bracts near the stem end with their sword-like mouth parts and sucking the sap. These minute punctures develop over a period of one week into long, deep, brown or black necrotic lesions. One puncture is sufficient to cause abscission of a very young nutlet and nutlets of up to 2 to 3 in. in length will absciss if punctured several times. Older nuts normally stay on the palm when damaged but growth of the nut is retarded in the immediate vicinity of the punctures, leading to a misshapen nut with a low copra content.

The major proportion of the damage resulting from *Pseudotheraptus* attack is in the loss of crop due to abscission of young nutlets. The relationship between the number of nutlets shed, consequent upon *Pseudotheraptus* attack and loss of crop, is a complex one because natural (physiological) shedding of undamaged nutlets occurs in addition.

However, evidence indicates that sustained control of *Pseudotheraptus* results in a substantial yield increase in the first year, although this may be followed by a depression in yield in the second year due to overbearing.

Control

(*a*) *Chemical*. The only spraying method which can be applied by peasant growers is the individual treatment of palms by climbers using small hand sprayers. At the time of writing the efficacy and economics of control by this means are being tested in the field. It is already clear that this method of control is not popular with the peasant growers and for the time being no general recommendation for the control of *Pseudotheraptus* by hand spraying is possible.

(*b*) *Biological Control*. The endemic red tree-nesting ant *Oecophylla longinoda*, locally known as the "*maji moto*" ant, commonly nests or forages in the crown of coconut palms. The ant is predatory on a wide variety of insect species including *Pseudotheraptus* and in addition feeds on the honey-dew excreted by others. Whenever *Oecophylla* is present in reasonable numbers in the crowns of coconut it affords those trees excellent protection against *Pseudotheraptus* attack. Unfortunately, it is rarely that as many as 20 per cent of the palms in any areas are effectively colonized by *Oecophylla*, and measures aimed at increasing *Oecophylla* populations in coconut plantations have been thoroughly investigated. The only measure which has met with success and is recommended is the interplanting of coconut with citrus or cashew trees, both of which are favoured by *Oecophylla*. Of these, citrus is only recommended in areas where it is known to yield well, and in the majority of cases cashew will be the preferred intercrop as it has a wide tolerance of soil and moisture conditions. Although *Pseudotheraptus* can feed on cashew apples and nuts, the resultant crop loss is small and is more than outweighed by the benefit derived by the coconuts from increased *Oecophylla* activity and the consequent reduction in *Pseudotheraptus* damage.

A thick ground cover of weeds also tends to increase *Oecophylla* populations, but this cannot be encouraged as the additional competition for soil moisture leads to a marked reduction in coconut yields.

MINOR PESTS

Rhinoceros Weevil (*Rhinostomus afzelii*)

The adult is a dull black long-snouted weevil which may measure from ½ in. to 1 in. in length. All stages may be found tunnelling in the trunk of an otherwise healthy palm, and eventually cause its death. Normally, attack will not be recognized until the palm is dying and it is too late to save the tree. Attacked trees must be felled and burnt to prevent spread of the pest to nearby trees.

Coconut Scale (*Aspidiotus destructor*)

This light fawn-coloured circular scale insect is approximately 1/12 in. in diameter and is found on both nuts and leaves. It is normally well controlled by natural enemies, in particular ladybirds of the genus *Chilocorus*, although localized outbreaks of some severity occasionally occur. Control measures are not recommended.

Other Minor Pests

A wide variety of scale insects, mealybugs, aphids and other pests occur on coconut. Attacks by these pests are generally of a sporadic nature, and do not warrant control measures. The most common are the small circular scale *Hemiberlesia palmae* and the aphid *Cerataphis ceretoniae*. The latter is shiny black with a white fringe, is sedentary and often mistaken for a scale insect.

A NOTE ON *ANALEPTES TRIFASCIATA* FABR. AND *PARANALEPTES RETICULATA* THOMS. (Coleop. Lamiinae) TWO TREE GIRDLING BEETLES OF TROPICAL AFRICA

By Tecwyn Jones, E.A.A.F.R.O., Muguga, Kenya

(*Received for publication on 7th February, 1961*)

The adults of the large black longhorn beetle *Analeptes trifasciata*, with their characteristic yellow banded elytra, were first encountered by the writer during a visit to the Northernmost areas of Ghana in October, 1958. The visit was made at the request of the Conservator i/c Northern Territories to investigate an apparently sudden outbreak of stem girdling on healthy trees of *Ceiba pentandra* growing alongside the main Navrongo —Tumu road.

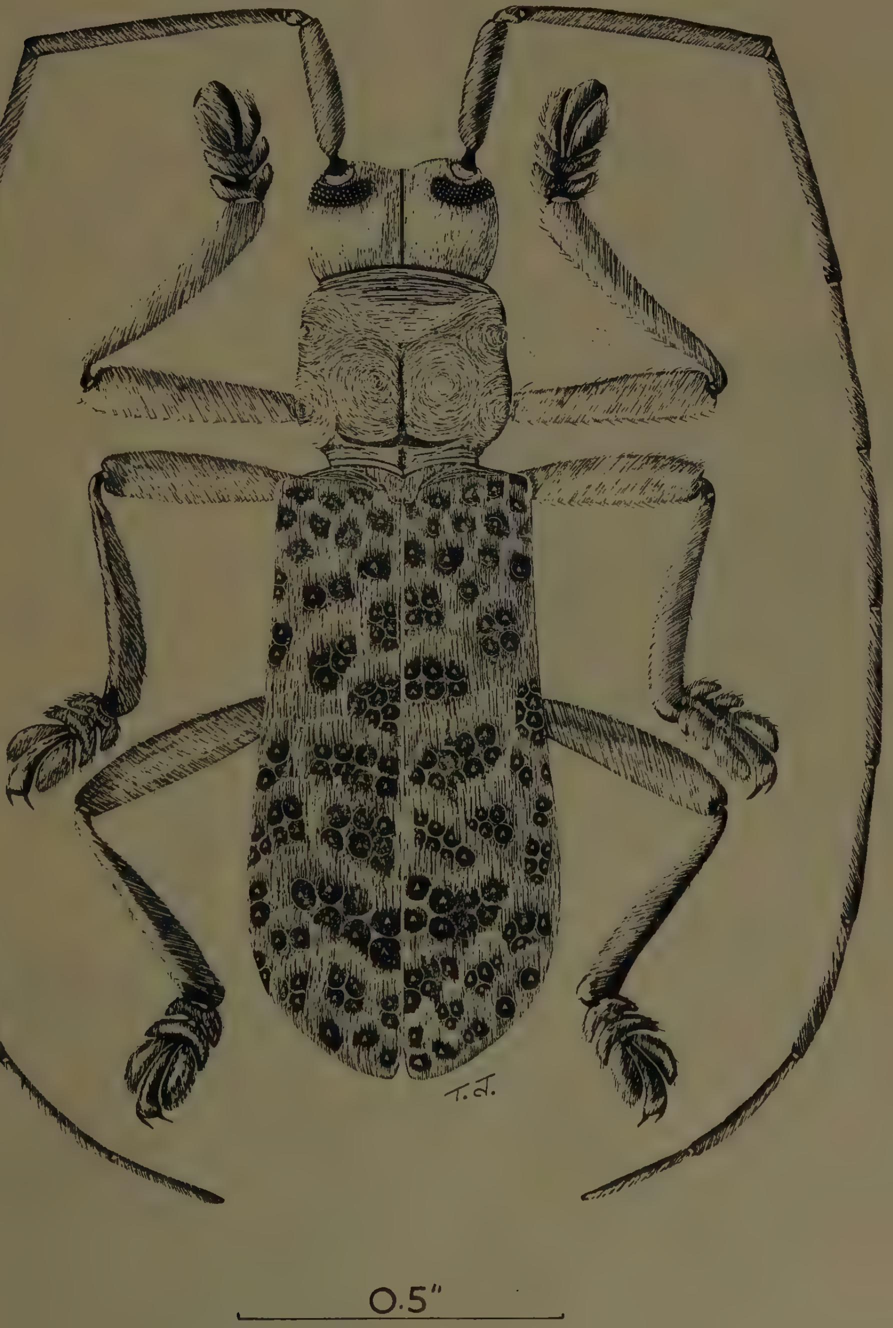
The trees, which were planted for the purpose of shade by the Land Planning Department some five years previously, had attained a height of 15-50 ft. and a girth at breast height of 1-5 ft. Prior to 1957/8 there were no records of attack by girdling beetles. Following the observations in the Navrongo area, reports of attack were subsequently forthcoming from the Paga and Bawku districts and the depredations of *Analeptes* were more widespread than was previously realized.

At the time of the visit, i.e. the dry season (October-April), the adult beetles were actively girdling their hosts. Main stems of three inches or so in diameter, and branches of similar size were being attacked. The girdles which included not only the bark but also the entire sapwood were spectacular and more reminiscent of beaver damage than longhorn attack. When completely girdled all that remained of the stem was a central pillar of a half to one inch thick. This was inadequate to support the stem and the latter eventually broke off. Attack on the main stem was, typically, about six inches above the first (i.e. lower) whorl of branches with the result that all growth above this whorl died and fell to the ground. Lateral branches subsequently became leading shoots, until they in turn succumbed to attack and were replaced by others. The net result of continuous attacks was that the trees remained stunted and developed multibranched stag-headed crowns. It was apparent from the profile of a number of the trees examined that *Analeptes* attack had proceeded unnoticed for perhaps two or three years in the Navrongo area, and the impression of a sudden outbreak in 1958 was a result of a gradual build up of attack until, in that year, damage was so extensive as to be apparent to the most casual observer.

A. trifasciata also occurs in East Africa, where Gardner has recorded an instance of it girdling *Lannea humilis* at Karamoja in Uganda. The closely allied species *Paranaleptes reticulata* which has identical habits is, however, more common in this region. This species was recorded as early as 1911 (Mostatt) girdling Kapok (*Bombax* sp) near Dar es Salaam, Tanganyika. Since then it has been found on *Anacardin occidentale* (Cashew), *Adenium* (Desert Rose) *Adansonia digitata* (Baobab) *Ficus*, *Acacia*, *Sterculia* and even *Casuarina* species in the Mombasa region of Kenya. Recently typical *Paranaleptes* damage was observed by the writer on a single tree of a roadside plantation of *Bombax* near Korogwe, Tanganyika and attacks have been recorded (5) on *Bougainvillea, Hibiscus, Citrus* and *Plumieria acutifolia* (*frangipani*).

The stem girdling habit of *Analeptes* and *Paranaleptes* is not unique, though the size of stem attacked is considerably larger than that recorded for most girdling longhorns. The purpose of girdling is to provide, in the form of deadwood, suitable breeding material for the larvae. These hatch from eggs laid singly in transverse slits under the bark of the stem above the girdle, and feed subcortically and eventually pupate in the fallen stem. Adult *Analeptes* emerge in Northern Ghana during the dry season, i.e. October to April, and *Paranaleptes* has been observed on the wing in October, November, April, May and July in East Africa.

Analeptes at present is more of a nuisance to ornamentals and shade trees than a serious pest of forest crops. Its attack on *Ceiba* in Ghana may not be as detrimental as it appears



PARANALEPTES RETICULATA

to be, because the resulting profile i.e. the low expansive crown provides equally good if not better shade than the normal tree. (This was certainly true in the case of *Khaya* species attacked by *Hypsipyla* in the same area). *Paraneleptes,* on the other hand, is a potential threat to the Kapok plantations and Cashew crop of East Africa, it is prudent, even now, to take certain precautionary measures. Good control could be obtained by simple sanitary measures such as collecting and destroying girdled stems within the plantations, *shambas,* and in the surrounding scrub, and so eliminating the larval population of the area.

Attention to the immediate surrounding areas is important and very necessary if the indigenous beetle population, breeding in natural "wild" hosts, is to be reduced and the chances of constant invasion of the plantations are to be minimized. The full range of wild hosts is not known for either species but there is considerable evidence to suggest that certain indigenous members of the Bombacaceae serve as natural hosts. The beetles are known to attack and breed in these species, e.g. in the Dar es Salaam and Mombasa areas, and it is interesting to note that in each area where the beetles have been found, at least one member of the Bombacaceae is indigenous to the local flora. For example in N. Ghana, the baobab *Adansonia digitata, Bombax costatum* and *B. buonopozense* are common and widespread; in the Dar es Salaam and Mombasa areas of East Africa, *Adansonia,* and *B. rhodognaphalon* occur in considerable numbers, and finally in Uganda (vide Kerfoot) *Adansonia* is found in the Karamoja area. These few species alone could suffice to maintain a reasonable population of girdlers and form an epifocus of infection of other suitable but unusual hosts. In addition, certain exotic Bombacaceae such as *Ceiba* in Ghana and *Ceiba* and *B. buonopozense* in East Africa may now, in view of their long establishment, be classified as natural hosts.

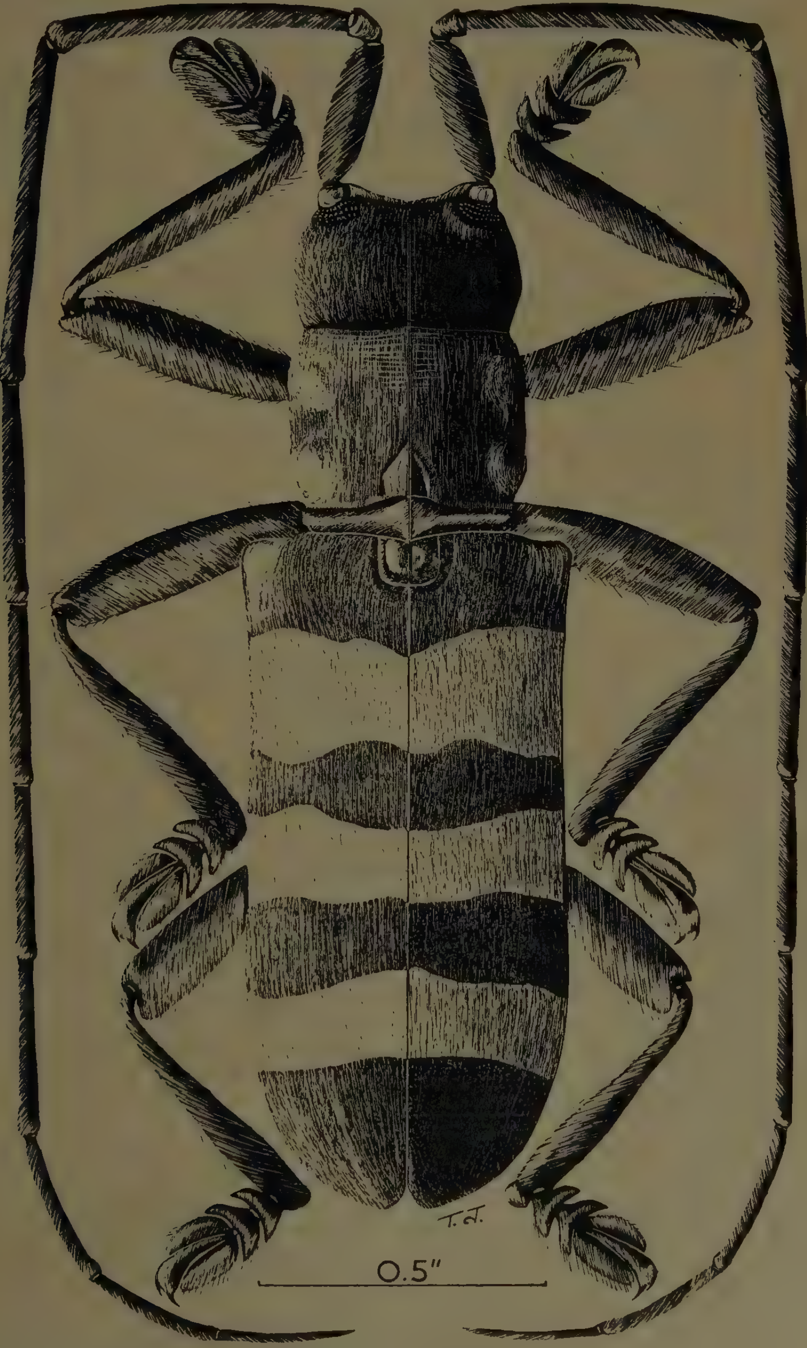
It is interesting to note that *Paranaleptes* attacks Sterculiaceae, a family closely related to its natural hosts and that both this species and *Analeptes* attack Anacardiaceae in widely separated areas.

SUMMARY

An outbreak of stem girdling on *Ceiba pentandra* in Northern Ghana is described and attributed to *Analeptes trifasciata.* A record of similar damage by the same species is quoted from Uganda whilst instances of *Paranaleptes reticulata* attacking various indigenous and exotic trees are reported from Kenya and Tanganyika.

P. reticulata is considered to be a potential pest of Kapok and Cashew in East Africa and it is suggested that simple control measures be instigated in and around existing plantations and *shambas.*

The wild host complex of both girdlers is discussed and it is suggested that the indigenous Bombacaceae are the natural hosts, but may be supplemented by certain exotic species such as *C. pentandra* and *Bombax.*



ANALEPTES TRIFASCIATA

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CONFERENCE ON LAND MANAGEMENT PROBLEMS IN AREAS CONTAINING GAME: LAKE MANYARA, TANGANYIKA

20th–22nd February, 1961

Reported by H. C. Pereira, E.A.A.F.R.O., Muguga, Kenya

PART I

SUMMARY

The object of the meeting was to learn of the range and scope of studies in progress and to exchange evidence and experience. No formal resolutions were taken, but in the opinion of the scribe the following points indicate the consensus of evidence and opinion on the successive subjects discussed.

1. *Food Preferences*

While there is undoubtedly direct competition between plains game and cattle for the best grasses, such as *Cynodon dactylon*, there is also good scientific evidence that many game species make preferred use of types of fodder which are not eaten by cattle, except in emergencies.

2. *Capture Techniques*

These have reached the stage of efficient research tools and have facilitated studies of productivity, population dynamics and disease incidence.

3. *Carrying Capacity for Game or Cattle*

Trained observers, basing their estimates on population sample counts, believe that semi-arid acacia-savannah country can carry very much heavier standing crops of edible animal protein in the form of mixed species of wild game than can be carried as domestic stock. The concentrations of herded stock do more damage to soil and vegetation than concentrations of game an order of magnitude greater.

4. *Game Populations*

Predation, disease and poaching are together reducing very rapidly the Wildebeest populations over the Loita-Mara plains. Detailed counts indicate a reduction by 55 per cent in two years. Populations on the Serengeti were believed stable.

5. *Efficiency in Protein Production*

Evidence that some game species may have a higher efficiency than domestic stock in the production of animal protein per acre of marginal semi-arid country is, although rather fragmentary, already too substantial to ignore; this is of particular importance where public money is being spent in development of semi-arid areas of which a technical knowledge is inadequate for planning. There is a strong case for intensification of research into these aspects of land use in marginal areas.

6. *Control of Cattle Diseases*

Ample veterinary evidence was put forward to establish that the efficiency of protection of domestic stock from disease is substantially reduced by the presence of *migrant* wild game. There is some evidence that this problem is greatly reduced where isolated game populations are resident together with protected cattle as in large ranches or in areas isolated by settlement.

7. *Game Harvesting and Marketing*

The very large scale on which poaching is now conducted in East Africa demonstrates the presence of a continuing market for game meat. Financial support is needed for pilot schemes for harvesting, marketing and distribution of game meat in order that game animals may be seen by the local populations to be a natural resource productive of income.

8. *Control of Game Populations*

When game is fully protected, population control can become essential to prevent destruction of habitat.

INTRODUCTION

Some 50 officers, whose work includes detailed technical studies of scientific aspects of this group of problems, met for three days to exchange information under the chairmanship of Dr. E. W. Russell, C.M.G., Director of the East African Agriculture and Forestry Research Organization, Muguga. Agricultural, Veterinary, Game and National Parks Departments from the three East African territories were well represented. Both Northern and Southern Rhodesia sent specialists while others attended from the three High Commission Research Organizations at Muguga and Sukulu respectively and from the Makerere Veterinary School. Wild life specialists from the U.S.A. working in East and Central Africa played a key part in the discussions.

Dr. Russell first explained the purpose and scope of the Conference. The object was to raise the productivity of the very extensive semi-arid areas in which neither arable cropping nor intensive cattle raising are possible. The Conference would deal with technical problems only. The I.U.C.N. and C.C.T.A. are proposing to hold a conference in East Africa later this year in which political and administrative aspects of these problems will be discussed. One of the principal requirements on the technical side is to define the problems which most urgently need research. The three territories of East Africa are not, technically, backward, they are just desperately short of money and of resources to carry out the technical and development work needed. By pooling their experience from different disciplines, members can help to achieve agreement as to where we most need assistance from overseas in solving the problems of the semi-arid areas. Dr. Russell then introduced Chief Fundikira, Tanganyika's new Minister of Lands.

In declaring the Conference open, Chief Fundikira assured the meeting that the Tanganyika Government was extremely concerned to make the best use of its natural resources of land and wild life and was determined to encourage this scientific study.

This brief account is intended to include the major points in both papers and discussion. Much valuable discussion and information has perforce to be omitted in order to keep within an acceptable length. A bibliography of all reference quoted in the papers is available from the E.A.A.F.R.O. Librarian, P.O. Kikuyu, Kenya.

SECTION I—THE FODDER PREFERENCES OF THE PRINCIPAL SPECIES OF GAME COMPARED WITH THOSE OF DOMESTIC STOCK

Paper No. 1.—"Preliminary Results on Determination of Foods Eaten by Some East African Wild Ungulates", by Lee M. Talbot and Martha H. Talbot, Wildlife Research Project.

Mr. and Mrs. Talbot are conducting a Wild Life Research Project in close co-operation with the Game Departments, National Parks and the Kenya Veterinary Department using the High Commission laboratories at Muguga as a base for operations. Mr. Talbot outlined in this paper the methods available for collection of data and explained why under the circumstances of their study the best method had proved to be the shooting of animals, after observed eating, followed by the immediate collection of swallowed food before it had been altered by digestion. Data had so far been analyzed from 248 animals of some 15 species. A study of the recognizable food fragments showed that 22 forms of food each accounted for more than 2 per cent of the total. Competition with cattle was direct only for the main three or four grass species of which Star Grass, *Cynodon dactylon,* is most important. A wide variety of plant species are utilized by game.

In the following discussion, Mr. Lamprey, Game Biologist of the Tanganyika Game Department, described the results of some 10,000 observations of individual animals browsing and grazing in circumstances where the species of vegetation is easily identifiable. He also found Star Grass to be by far the most important preferred food. He agreed that the observation method was not reliable when short grasses were being heavily grazed by groups of animals of different species as in the Plains study of the Talbots.

Mr. Stewart, Game Biologist of the Kenya Game Department, described his initial calibration study of faecal residues. Although this needs much preliminary work and suffers as a method from selective digestion of soft leaf as compared with the roughage components of animal diet, there are advantages which make the method worth while pursuing.

The fistula technique by which samples are automatically collected from the oesophagus or from the rumen had given definitive information about selective grazing by domestic stock and deer in the U.S.A. This was already under trial at Muguga in co-operative work between E.A.A.F.R.O. and E.A.V.R.O. and might eventually be applied to fuly tamed game animals. It was agreed that the game harvesting schemes now beginning on a pilot scale in East Africa might provide much material for stomach contents studies.

All observers agreed on the very decided preference shown by many species of game for young grass. Wildebeest herds presistently followed rainfall. A very wide range of grass species are eaten when newly sprouted but there are marked differences between game species in the extent to which grazing continues as the grass matures. Wildebeest lose interest when the grass reaches 6 in. or more high while Topi continue to eat grass in the dry stage.

The degree of fouling does not appear to have a major influence on selection of grazing areas although it might well become important if game were confined within restricted boundaries.

Section II—Progress in Capture-Techniques for the Study of Wild Animals

Paper No. 2.—"Advances in the use of muscle relaxing drugs for immobilization and handling of the larger land mammals", by A. M. Harthoorn and J. A. Lock. Makerere Department of Animal Physiology.

Dr. Harthoorn described the capture-drug technique as having reached the stage of an efficient tool for studies of elephant and hippo. This permitted individual marking for study of movement of these species.

There was no likelihood of the general application of one drug to all species. Careful physiological study was required. The relaxation of muscles could not be confined to those of locomotion only; respiratory muscles were also affected. In the rhino, for instance, antidotes must be given within minutes. The Uganda Kob, being similar in structure to the goat, was easily matched, but very high or very low blood pressures in other species made careful selection of drugs and calculation of dosing of drugs essential. Even then, far greater mortality must be accepted than in veterinary practice. The opportunities for study of parasites and blood stream pathogens in temporarily immobilized animals was most valuable.

Paper No. 3.—"A review of the current position of field immobilization in East Africa", by Lee M. Talbot and Martha H. Talbot. Wildlife Research Project.

After paying tribute to the development work by Drs. Buechner, Harthoorn and Lock in Uganda, Mr. Talbot described joint work with Mr. Lamprey on capture and marking of game species in Tanganyika and mentioned Mr. Carter's work in capture and transfer of rhinoceros in Kenya. The Wildlife Project on which he and Mrs. Talbot were engaged made intensive use of capture drugs (*E.A. agric for. J.* 1960, page 92).

The requirements are for a drug with a high margin of safety and a high speed of action. No single drug yet tried in East Africa satisfies all these criteria over many species. In order to establish the pattern of reaction to changing dosage rates, preliminary experiments have been made on domestic cattle where other variables can be better controlled.

Most of the work described had been done on the Wildebeest for which the drug Gallamine Triethiodide now provides an efficient means of capture.

Throughout East Africa the capture techniques have made possible the transference of many game animals as an alternative to their destruction.

Discussion

No drug yet known could be given irrespective of dosage, so that treatment of water holes or troughs was not practicable. The game is paralyzed, not anaesthetized, by muscle-relaxant drugs, and the animals are aware of their subsequent handling. Prompt administration of tranquilizers is useful for transport and these also improve breathing by minimizing the effects of overdosing with muscle-relaxing drugs. Blindfolding is a routine precaution. When released after capture and marking, animals are not subsequently found to be more wary or difficult to approach.

Section III—Use of Light Aircraft

Paper No. 20.—"The use of light aircraft in East African wildlife research and game movement", by D. R. P. Zaphiro and Lee M. Talbot.

Paper No. 21.—"Aerial analysis of wildlife population structures", by Lee M. Talbot and D. R. P. Zaphiro.

A convincing exposition of the advantages of the use of a slow-flying high-wing monoplane in game study and management was given by Mr. Zaphiro of the Kenya Game Department. The need to acquire thorough mastery of the handling of the aircraft before distracting 90 per cent of the pilot's attention to game observation was readily appreciated by the meeting.

Sampling estimates from air and ground had given excellent agreement in open country, and for elephant and rhino in bush country. In thicket vegetation Impala counts were much higher from the ground. With Mr. Talbot, a method of estimating the sex ratio of Wildebeest groups was described. When disturbed the bulls took up defensive positions on the perimeter, while the cows and calves went to the centre. Control of poaching, cattle trespassing and other management problems were greatly simplified. The Tanganyika National Parks had newly acquired an aircraft for this work.

SECTION IV—POSSIBILITIES OF USING GAME SPECIES FOR PROTEIN PRODUCTION ON MARGINAL LAND

Paper No. 4.—"The possibility of using wild animals for animal production on East African rangeland", by Lee M. Talbot, H. P. Ledger and W. J. A. Payne (E.A.A.F.R.O. Animal Husbandry Division).

Based on a paper to the 8th Int. Congress of Animal Production (in the press).

In East Africa the main deficiency in human diet is animal protein. Very large areas of undeveloped semi-arid country have shown poor returns from domestic cattle. Difficulties of management in the marginal areas are acute. Extreme fluctuation in rainfall distribution, combined with high temperatures and sparse watering points, render this type of country extremely vulnerable to denudation, erosion and desiccation. Tsetse fly has denied large areas to cattle and these areas have thus escaped severe deterioration from over-grazing. Even *Bos indicus* is a comparative newcomer to East Africa and the animals better adapted by nature to this environment may provide a more efficient source of animal protein. In comparison with cattle many game species utilize a wider range of the vegetation flora and can make use of range at greater distances from water points; they are tolerant to trypanosomiasis and can therefore make use of tsetse-infested country. Species potentially useful for meat production include Wildebeest, Zebra, Eland, Grant's and Thomson's Gazelle, Kongoni, Buffalo, Impala, Topi, Oryx and, in certain regions, Giraffe, Elephant and Hippopotamus. Because of widely different food preferences many species can thrive in the same habitat.

Most game species have a higher yield of edible meat, as a proportion of live weight, than is found in cattle; the killing-out percentages of both Grant's and Thomson's Gazelles, Impala and Eland all being about 60 per cent, while cattle of the African pastoral tribes rarely exceed 50 per cent. There is some evidence that Eland, which are readily domesticated and have already received some study, have a higher rate of live-weight gain and an earlier maturity than have cattle in similar circumstances. Estimates of observed carrying capacity of Acacia savannah were quoted by Mr. Talbot to show that very much heavier standing crops of game thrive without damage to the habitat, while smaller standing crops of cattle, in Masailand, cause severe land deterioration. Improvement of cattle ranching needs capital and skilled organization; the game is already there.

The greatest need at present is for work on harvesting, distribution and marketing of game as a continuing crop.

Paper No. 5.—"The use of carcass analysis techniques for investigating the meat production potential of game and domesticated animals in semi-arid areas", by H. P. Ledger and W. J. A. Payne (E.A.A.F.R.O.), Lee M. Talbot (E.A. Wildlife Project), and D. Zaphiro (Kenya Game Department).

Mr. Ledger presented this paper and emphasized that domestic livestock producers are highly selective in both the species and strains of animals for contrasting environments. Species, selected from pigs, cattle, sheep and goats, were highly adapted by specialized breeding for different forms of intensive or extensive farming. The semi-arid areas need capital expenditure on water, roads, fencing, etc., to permit domestic stock to make use of their very low intrinsic productivity. The level of animal nutrition in these areas can not be raised economically. It is therefore logical to seek other species better adapted to conversion of the existing fodder to meat.

Fat is the most uneconomical of animal products, and is more efficiently extracted as vegetable fats and oils than after conversion in the animal. The essential contribution of the animal to human diet lies in its high quality protein. Even lean cattle, giving dressed carcass weights only 45 per cent of liveweights, average about 18 per cent fat while a finished steer, killing out at 50 per cent, averages 28 per cent fat. An over-fat steer can carry 35 per cent of fat. The game animal carcasses which he had analyzed in the Meat Research Unit at Muguga had killing-out percentages of about 60 per cent but only 4 per cent of the dressed carcass was fat.

The proportion of lean meat in the carcass which, according to Professor Callow is approximately 33 per cent and varies little among breeds of cattle, is 32 per cent in the Zebu at Muguga and 32 per cent in the goat at Mpwapwa, Tanganyika. At Muguga, however, Wildebeest carcasses averaged 42 per cent lean meat while Thomson's Gazelle averaged 46 per cent. Several pages of detailed data were presented as an appendix to this paper. The game species were thus shown to produce more lean meat and less fat and bone than do domestic cattle.

Dr. A. S. Mossman, Fulbright Scholar in Wildlife Management, gave an account of similar findings as a result of an experimental game-cropping scheme near Bulawayo. The average killing-out percentage of the Impala was 61 per cent. This was the main species cropped; 300 had already been marketed through the Cold Storage Commission.

Paper No. 6.—"Some aspects of game cropping", by Dr. A. M. Harthoorn, Department of Animal Physiology.

Dr. Harthoorn surveyed the present experience of game-cropping in East and Central Africa and elsewhere. He discussed briefly the difficulties due to diseases such as anthrax, and food hygiene aspects of field slaughter and butchering. The use of capture drugs, followed by slaughter and correct bleeding procedures, may improve the efficiency and safety with which large animals may be harvested. In addition to poaching, licensed hunting in Uganda supplies a great deal of the meat for local populations. Crude but effective distribution and marketing arrangements already handle large quantities of meat annually.

In the discussion, work at the Kabete Veterinary Laboratories was quoted as finding both Zebra and Wildebeest carcasses to yield 30 per cent of liveweight as meatmeal and bonemeal, as compared to 31 per cent-32 per cent for scrub cattle.

The presence of measles in game meat was discussed at some length. The symptoms were common, but the species of tapeworm were associated with jackal and hyena rather than with the domestic dog, so that transmission to man was improbable. None of the several hundred game carcasses submitted for inspection in Southern Rhodesia had been condemned. Many present had lived on game meat for substantial periods without ill-effect. Incidence of measles in Masai cattle was, however, reported as very high. No laws at present cover inspection of venison in East Africa.

Paper No. 7.—"Metabolic stress and nitrogen excretion", by H. G. Livingston. E.A.A.F.R.O. Animal Husbandry Division.

In the absence of Dr. Livingston, his paper was presented by Mr. Ledger. As detailed nutritional studies are extended into semi-arid areas an outstanding anomaly is evident. Indigenous cattle gain weight on pastures whose chemical assessment indicates less than a maintenance ration. The Animal Husbandry Division of E.A.A.F.R.O. is following two alternative hypotheses. Either the cattle are selecting high-value herbage or they possess ability to extract more nutrients from poor herbage, and to waste less of those extracted than has been hitherto understood.

For the tropical ruminant the work of Schmidt-Nielsen (1959) has shown that the camel can re-process waste urea. There is some evidence that Merino sheep have a similar ability. The reduction in urea excretion gives important economy in the use of water as urine. Zebu cattle and game animals, adapted to periodic low protein diets, may have this mechanism and its investigation is important. Comparison of nitrogen levels in blood, saliva and urea of exotic and indigenous cattle on high and low protein diets, using identical twin sets, is in progress at Muguga. In collaboration with the Game Departments of East Africa, similar studies are commencing for game species.

In the discussion, the conclusion that animals adapted to use of low-protein forage would also show the least need for water was confirmed from the experience of the game specialists present. The advantages of the mobility of game in exploiting their habitat and the destructiveness of cattle whose corresponding mobility involved return to fixed bomas and water points was described by several speakers.

Paper No. 8.—"A method for determining weight of wild animals from external body measurements", by Lee M. Talbot and J. S. G. McCulloch (E.A. Wildlife Research (E.A.A.F.R.O.) Project).

Mr. Talbot described the external body measurements taken on both immobilized and killed animals. These, and the method of weighing, were subsequently demonstrated in the field. Dr. McCulloch of E.A.A.F.R.O. had analyzed the data statistically and had suggested that while useful results could be obtained using a polynomial form of regression, the equation had no physical meaning. Use of the product of length and girth to give the dimensions of volume held more promise. The external measurements, for the 100 beasts examined, were capable of predicting live weight with a standard error of only 5 per cent. Elimination of the weights of viscera and of stomach fill on a subsample of 16 animals did not show any improvement in accuracy.

"Range management", by Leslie Brown, Kenya Department of Agriculture.

In a brief talk on range management, Mr. Brown deplored the lack of men and money allotted to research on land-use in ranching areas of East Africa. Much use of marginal land for cultivation, developed at public expense, was following the earlier mistakes of the U.S.A. Even where commercial ranching is in skilful hands, there is evidence of slow deterioration of rangeland and invasion of bush species. In some African areas, less skilfully used, this process had reached the final stage of continuous dense bush cover with grasses excluded. It was doubtful whether man would ever be able to manage marginal ranch land efficiently with the present narrow range of species of domestic stock. Game species, adapted to make use of a wider range of forage, may well prove essential. Research was needed as a matter of urgency before further public money is spent in developing marginal areas with the inadequate knowledge at present available.

In the following discussion, there was strong support for the thesis that beef should be produced at higher efficiencies under intensive development; there was no economic excuse for the severe deterioration of very large areas of semi-arid land in order to produce cattle at very low efficiency. There was large-scale evidence of deterioration of open grasslands to bush and rock wilderness. Game specialists reported significant changes in the occurrence of game species as the natural fauna adjusted to the changing environment.

In the western U.S.A. large areas of rangeland were now showing steady improvement as simple rules of management were applied, although complete non-use had produced deterioration. Intensification of water development rendered more urgent the need for better management. United States experience in National Parks had shown that wild species could also lose adjustment to their environment, and the population, e.g. of elk, needed management to avoid destruction of habitat. An East African example is provided by the populations of elephant in Uganda—settlement has reduced their habitat to one-sixth of their original range but the population numbers had not accordingly changed. Forest reserves, game parks and sanctuaries are becoming overstocked. Traditional migration routes have been blocked by settlement. Since 1927 45,000 elephant have been shot on control operations; 8,500 of these have been killed by licensed hunters who sell the meat to the local population. More control is needed each year since the elephant are rapidly destroying their habitat. Similar observations were reported from the Mara where fire made spectacular inroads into riverine forest and thicket after damage by large concentrations of elephant (a single herd of about 400 has been seen).

The problems of grazing rotation and resting of pastures with mixed populations of game and cattle were raised. Where large populations of wild game were present, pastures rested from cattle were heavily grazed by game; no solution to this difficulty was suggested. Experience in Southern Rhodesian ranches with very large paddocks had so far been more promising. Game populations tended to stay in the same pastures and to respect fences.

Paper No. 9.—"Preliminary findings of the population dynamics of the wildebeest in Narok District, Kenya", by Lee M. Talbot, Wildlife Research Project.

Mr. Talbot pointed out that for management of either game or cattle knowledge is needed of rates of reproduction, rates and causes of mortality and ratios of males to females. His paper presented a summary of the population dynamics of Wildebeest in the Narok District. This is the key species for any game cropping scheme in this area and for study of interaction with cattle populations. Detailed prolonged observations from fixed posts combined with strip sample counts and surveys by both vehicle and aircraft were supplemented by long cross-country journeys, keeping individual groups under continuous observation. Collections throughout the year have been made in co-operation with the Kenya Game Departments, Kenya Veterinary Department, E.A.A.F.R.O. and E.A.V.R.O., to secure the maximum information from each animal shot.

Reproduction rates are high, 95 per cent of all females of over one year of age produce a calf each year. Mortality rates are even higher. The primary cause of adult mortality is predation. Between 200 and 300 lion and a very large population of hyena, together with leopard, cheetah and hunting dogs, account for some 4,000 wildebeest a year. Predation is particularly severe in young calves, and in the past two years in the Narok District has amounted to about 45 per cent of the total calf crop. There is additional loss of calves separated from their mothers when large herds are disturbed. A disease, believed to be rinderpest, also takes a heavy toll of calves six to ten months old. During the past two years the total mortality in the annual calf crop during the first year of life amounts to 85 per cent. All known factors lead to an estimated fall in population of 17 per cent per year. The total population of Widebeest has, however, dropped sharply by about 55 per cent in two years in the area studied. These losses cannot be accounted for in full by observed predation and disease.

In the ensuing discussion the meeting was startled to learn that Game Department officials believe that poaching losses near to the Tanganyika-Kenya border amount to "hundreds per month" so that a substantial part of this big fall in population may be due to poaching.

Mr. Talbot recommended that the region of the Serengeti National Park and the Narok District of Kenya should be treated as a single ecological unit. Marked animals have been traced from the Mara to the Serengeti. By the planned use of fire, game should be led to use the northern extension of the Serengeti Park. At the present rate of mortality the population of Wildebeest in the Loita Plains, Narok-Mara area is too small to maintain itself. Before game-cropping is attempted, steps must be taken to reduce this mortality rate. In the Serengeti, however, the population is of the order of 100,000 Wildebeest, which can maintain itself even against an 85 per cent calf mortality.

A number of speakers challenged the accuracy of the means of age determination in game animals, since cattle were known to show very wide variations in the timing of their teeth eruption.

The Game Biologists described the body dimensions, horn diameters, degree of wear on teeth and other supplementary factors which were taken into account by full-time research workers. They were satisfied that the determinations were of sufficient accuracy to determine growth curves over large numbers of animals.

(To be continued in the October issue of the Journal. Part II contains accounts of discussion and papers on animal disease problems, on marketing and on the Ngorongoro Conservation Area.)

REVIEW

THE DEVELOPMENT AND WORK OF THE GRASSLAND RESEARCH INSTITUTE, Hurley, England, by W. Davies

EXPERIMENTS IN PROGRESS, 12: Ann. Rept. (1958-59) of the Grassland Research Institute, Hurley, England. 112 pp. Price 7*s.* 6*d.*

For those who do not already know of the good work carried out by the Grassland Research Institute, the first publication is a very good guide. It is short and very much to the point in that it describes the foundation and outlines the work of the Institute within some 14 pages of text and four pages of photographs.

The annual report gives the work of the Station in detail for the period 1958-59. The overall programme is a study of grass/animal/soil complex which involves a study of herbage, animal and ley agronomy among many other things.

A NOTE ON MAGNESIUM UNBALANCE SYMPTOMS IN AVOCADO PEAR TREES

By J. B. D. Robinson, Coffee Services, Department of Agriculture, Kenya*

(*Received for publication on 23rd January, 1961*)

Avocado pear trees growing on the Kikuyu red loam coffee soil at the Coffee Research Station, Ruiru, frequently exhibit an interveinal chlorosis followed by necrosis of the distal leaf edges as illustrated in the accompanying photograph (Plate I). In the early stages, chlorosis symptoms are similar to those illustrated by Brusca and Haas (1960) and attributed to magnesium deficiency.

It is known that coffee (*Coffea arabica*), Robinson and Chenery (1958), Washington navel orange, roses and several other ornamental shrubs all exhibit visual symptoms of magnesium unbalance when growing on this soil type and that they respond to soil and/or spray applications of Epsom salts, Robinson unpublished data). It seemed possible, therefore, that the symptoms illustrated in Plate I might also be caused by a magnesium unbalance.

Analytical Results

From time to time Avocado pear leaf samples were collected from trees growing on the Coffee Research Station, Ruiru, which exhibited these symptoms and were analysed for their calcium potassium and magnesium contents.

The age and type of leaf sample collected is shown in Plate I; young, green leaves are those designated "A" and old chlorotic/necrotic leaves are those designated "B".

In Table I are shown some typical analytical values together with a summary of some comparable figures found in the literature and referring to work carried on outside Africa.

Table I.—Calcium Potassium and Magnesium Content of Avocado Leaves

Sample Description		% Ca	% K.	% Mg	Reference
		(in leaf dry matter)			
Coffee Research Station, Ruiru I A*		1·74	0·86	0·35	—
Coffee Research Station, Ruiru I B*		1·70	0·94	0·22	—
Coffee Research Station, Ruiru II A		1·59	0·95	0·19	—
Coffee Research Station, Ruiru II B		1·53	0·86	0·19	—
Coffee Research Station, Ruiru III A		1·58	0·87	0·24	—
Coffee Research Station, Ruiru III B		1·58	0·88	0·26	—
San Diego County, California. Leaf age equivalent to 'A' sample, Healthy trees.	Mean (of 12)	1·76	0·917	0·717	Aldrich, Coony and Goulben (1952).
	Range.	1·43–2·07	·674–1·228	·502–826	
California. Comparison of green leaves with leaves about to fall, Healthy trees.	Green.	2·33	1·18	0·54	Cameron, Mueller and Wallace (1952).
	About to fall.	2·29	0·89	0·50	
California. Healthy, mature leaves.	Mean (of 6).	2·05	1·10	0·66	Haas, (1949).
	Range.	1·40–2·64	·87–1·57	49–·79	
Magnesium chlorosed leaves		1·68	—	0·36	
Low Calcium and Magnesium—					
Sample 1		1·25	1·29	0·52	
Sample 2		1·30	1·38	0·46	

*A and B are leaf ages at sampling time as shown in Plate I.

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* Present address: Coffee Research Station, Lyamungu, Moshi, Tanganyika.

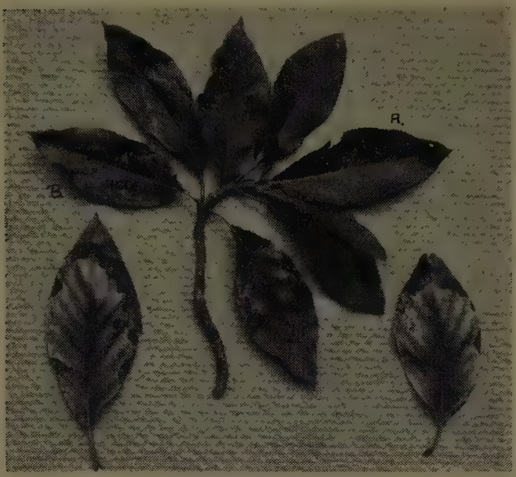

Plate I

Avocado Pear leaves showing (1) Later stages of visual magnesium unbalance symptom (note interveinal chlorosis and necrosis progressing inwards from the distal leaf edges). (2) Leaf age of the different leaf samples, designated A (young) and B (old) leaves.

Brusca and Haas state "the dry matter of healthy avocado leaves usually contains about 0.7 per cent magnesium". By comparison with the leaf values in Table I obtained from other sources it is tentatively concluded that the chlorosis/necrosis symptoms exhibited by the older avocado leaves collected from trees growing on a Kikuyu red loam soil at the Coffee Research Station, Ruiru, Kenya, is due to a magnesium unbalance amounting to a shortage of that element in the leaf. Leaf values for calcium appear to be average whereas potassium values are slightly low in the young green leaves (A) when considered alongside comparable figures quoted from the literature.

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REVIEW

FARMING FOR PROFITS, by Keith Dexter and Derek Barber, published by Penguin Books Ltd., Harmondsworth, Middlesex, 1961. 300 pp. Price 5*s*.

Farming for Profits is a timely reminder that whilst technical advances in farming practice may result in increased yields it is by no means certain that such increases will be accompanied by increased or any profits.

On the hypothesis that the majority of farmers are "in the game" to make money, the authors have not fallen into the error of attempting to show that cash returns in themselves are the be all and end all of successful farming. Indeed the first 30 or so pages deal entirely with the human aspect of farming, making it clear that the aspirations of individual farmers are important factors when assessing the best way in which technical skill can be turned to profitable advantage.

The authors then proceed to provide a number of yardsticks, based on U.K. farming returns, by which farmers can compare their profit-making ability with others. For example, the question is asked: "What about your net income? If you have less than 100 acres are you making at least £15 an acre? Many farmers are making £20 or so per acre. If you have more than 100 acres. . . ."

Having provided this and other datum lines from which to work, the authors proceed to explain, very clearly, how to examine one's own farming system for faults which may be causing low returns.

The profitable use of capital and credit are also discussed and the financial implications of dairying, beef and sheep, pigs and poultry, arable, small and hill farming are dealt with in some detail. A useful appendix is provided dealing with the calculation of output, costs and net income, information on budgeting manuals and how to obtain advice.

That the basis for the costings is the current price ruling in the U.K. detracts little from its value for it provides stimulating and easy reading for both the farmer and the agricultural adviser and can do much to increase their mutual understanding.

The senior author, Dr. Dexter, is currently serving with the Ministry of Agriculture, where he is a Principal Agricultural Economist. His co-author, Mr. Barber, is County Advisory Officer for Gloucestershire.

This book, whose principles are of generel application anywhere in the world, can be recommended to everyone interested in agriculture.

A COMPARISON OF STANDING HAY PRODUCTION FROM GRASSES AT ENTEBBE

By K. W. Harker, Animal Health Research Centre, Entebbe

(*Received for publication on 3rd January, 1961*)

The normal methods of conserving herbage in temperate climates, silage making and hay making are not usually practised on Uganda farms. If there is any surplus grass during the growing season it is usually left *in situ* for subsequent use. This excess herbage in the dry condition is usually referred to as "standing hay".

Excess herbage can be allowed to accumulate for many months, sometimes for over 12 months. In formulating management practices, therefore, it is necessary to know the behaviour of grasses under this system of accumulated herbage.

The results given in this paper indicate the yields of standing hay to be expected from four grass species grown under the variable rainfall conditions at Entebbe. The species chosen were grasses which can either be planted from seed or which can be established readily by vegetative propagation.

MATERIAL AND METHODS

Five blocks of land, each approximately 15 ft. wide by 40 ft. long, were sown or planted with grasses. Blocks I and II were planted with runners from wild plants of apparently different strains of *Cynodon dactylon*. Blocks III and IV were sown at a rate of 15 lb. per acre of *Melinis minutiflora* seed and 20 lb. per acre of *Chloris gayana* seed respectively. Block V was planted with cuttings of *Paspalum notatum*.

On 15th March all the blocks were topped over with an Allen autoscythe leaving approximately 1 in. of stubble. The cut herbage was removed from the blocks and pegs were inserted to mark the rows of plots each approximately 40 in. square.

At each cutting date, two samples from each block were taken systematically in order to reduce the effects of soil differences on the difference between consecutive months' cuttings. If a random cutting method had been adopted, the difference between monthly cuts would be due to a true difference of growth of grass exaggerated by inherent soil differences. In this trial it was assumed that the major soil trend occurred across the width of the blocks since this was the general slope of the ground. The first month's cuts were taken from the bottom of the first row of plots and from the top of the seventh row. The second month's cust were taken from adjacent plots above and below the first. That is, the second from the bottom in the first row and the second from the top in the seventh row. Similarly, the third and fourth monthly cuts were taken from plots above and below the previous cuts. The fifth cust were taken from the top of the second row and the bottom of the eighth row. Thus, whenever a plot was cut, it had one side common with the plot cut the previous month.

The cutting procedure was to use a rigid frame of 36 in. square, internal measurement, and to cut off the herbage with shears to within 1 in. of the ground. The samples were weighed fresh, dried in a stream of hot air and weighed. The complete sample was ground through a laboratory hammer mill and samples were taken for dry matter correction and for chemical analysis.

The first cut was taken on 10th April, and subsequent cuts were taken at approximately four weekly intervals. Each cut representing the net available growth from the initial clearing date; that is, young growth, old growth and decayed vegetation were all collected. Difficulties arose when the plots became invaded with the indigenous legume *Vigna gracilis*. During the first 12 months of growth, the quantity of legume was negligible but the growth developed strongly with the second season's rains.

The plots were kept clear by pulling the legume at approximately weekly intervals but labour difficulties and the continued growth of the legume resulted in the cutting being abandoned after the 14th cut.

RESULTS

The yields of oven dry matter based on the mean weights of the two samples, expressed as tons per acre; the percentages of crude protein and crude fibre in the dry matter are given in Table I. The results show that during the first month the rate of growth was high on all five blocks although the rates of growth of one

Cynodon (Block I) and the *Chloris* (Block IV) were the highest. The bulk of herbage increased considerably in the second and subsequent months but the species tended to behave slightly differently. With *Chloris gayana* peak production occurred in the second month and changed very little throughout the rest of the trial. In contrast the yields of *Melinis minutiflora* continued to increase steadily for six months, the greatest bulk being more than twice the greatest yield of the *Chloris*. The lowest yields were recorded on the *Paspalum notatum* plots.

The data for crude fibre and crude protein in the dry matter give an indication of the feeding value of the herbage. It will be noted that there are considerable differences between species. For most of the cuts the protein content in the *Cynodon* and *Paspalum* herbage was above the 6 per cent level whilst almost all cuts of the *Melinis* and *Chloris* herbage were below this level; most of the *Melinis* herbage was below 4 per cent. Similarly, the fibre content of the *Paspalum* herbage was below 30 per cent; the majority of the *Cynodon* herbage was above 30 per cent and more than half the *Melinis* and *Chloris* herbage was above 40 per cent. As the blocks of different species were adjacent these major differences must be regarded as species differences.

Some of the minor fluctuations can be attributed to the effects of rainfall and evaporation rates on the rate of regrowth.

During the first two "months" the rainfall was 6.06 and 11.34 in. respectively, whilst for the third to eleventh months inclusive the rainfall ranged from 0.74 in. to 5.35 in. per month with a mean monthly rainfall for this period of 2.37 in. Only during the fifth and tenth months was the rainfall in excess of the open water surface evaporation. The 12th, 13th and 14th months had 7.04, 6.22 and 13.51 in. of rain respectively, these being in excess of the respective monthly evaporations.

DISCUSSION

These results indicate the marked differences which exist between species when grown under similar conditions. These differences must be taken into account when consideration is being given to the grass species to plant and to the management of the species in any particular farming system.

Of the species used in this trial, only one, *Melinis minutiflora*, continued to grow for a long period. The disadvantage of this species, however, is that after the first two months of growth the protein level of the herbage may fall below level for productive use and hence this species must be used as a bulk food and will have to be supplemented with higher protein feed.

For most of the year an area of *Paspalum notatum* could be used in conjunction with a paddock of *Melinis minutiflora*. The *Paspalum* produced a small bulk of leafy material low in fibre and with a reasonable protein content. Therefore, saved herbage of this species could be grazed to supplement some of the deficiencies in the *Melinis*.

There appears to be no virtue in saving *Chloris gayana* herbage as standing hay. After the initial growth there was very little increase in bulk and in addition the protein content of the dry matter was at a low level most of the year.

For general purpose usage *Cynodon dactylon* would seem to be a reasonable choice. There was slight increase in bulk throughout the trial and the protein remained above the 6 per cent level almost all the time. Initially there appeared to be differences between the two strains used. Later, these differences became less apparent and towards the end of the trial the yields of both strains were affected by legume invasion.

The economics of the practice of standing hay production must be considered in relation to other management practises and other conservation methods. This is particularly true when considering the yield per acre of protein under various systems of management. In this trial the recovery of protein was fairly constant between the second and thirteenth cut irrespective of species, and only in the fourteenth cut was there any marked increase in the yield of protein. Small month to month fluctuations were due to the decomposition of old herbage and possibly to leaching from the plants. The yield of protein may be greater under a system of cutting at regular intervals than it is under this system of standing hay production but it is not possible to predict these results from the data in this trial.

ACKNOWLEDGMENTS

The author wishes to thank the staff of the Nutrition Chemistry Section and in particular Mr. Bredon for their assistance.

Table I.—The Yield of Dry Matter and the Percentages of Crude Protein and Crude Fibre in the Dry Matter for Standing Hay Cut at Monthly Intervals

Month	Block I Cynodon dactylon			Block II Cynodon dactylon			Block III Melinis minutiflora			Block IV Chloris gayana			Block V Paspalum notatum		
	Tons per Acre	% Crude Protein	% Crude Fibre	Tons per Acre	% Crude Protein	% Crude Fibre	Tons per Acre	% Crude Protein	% Crude Fibre	Tons per Acre	% Crude Protein	% Crude Fibre	Tons per Acre	% Crude Protein	% Crude Fibre
1	0·85	10·1	30·0	0·63	16·3	28·2	0·66	13·4	29·9	0·92	14·0*	34·5*	0·73	15·6	25·0
2	1·33	9·2	31·7	1·13	9·2	31·7	1·78	6·4	34·4	2·00	5·6	40·8	0·91	16·6	25·3
3	1·34	12·5	33·3	1·43	6·9	35·9	2·76	4·0	39·5	1·98	4·1	43·7	1·47	14·3	27·8
4	1·64	6·5	35·9	1·91	6·2	36·1	3·51	4·9	40·8	2·22	4·6	42·6	1·84	9·7	28·1
5	2·05	8·2	35·3	2·29	8·4	36·0	4·11	3·9	40·9	1·87	4·1	44·1	1·87	7·4	27·5
6	2·01	6·5	37·1	1·82	6·5	35·6	4·60	3·1	40·7	2·00	4·7	42·1	1·39	7·6	28·3
7	1·96	6·9	33·7	1·86	6·5	36·5	3·42	2·9	41·0	2·30	6·8	38·7	1·35	5·7	28·1
8	2·23	6·2	34·8	1·99	4·7	39·1	5·29	2·4	39·4	2·64	4·0	39·2	1·83	5·4	28·2
9	2·37	7·2	35·2	1·71	6·7	35·1	5·01	3·0	39·5	2·42	5·3	40·2	1·62	7·6	27·9
10	2·63	8·2	33·9	1·87	6·5	34·3	4·30	2·9	39·9	3·00	5·2	41·3	1·07	9·1	27·6
11	2·31	6·4	35·6	2·36	6·2	35·1	7·08	2·7	40·9	2·31	5·7	40·1	1·76	6·5	28·2
12	2·04	6·8	35·8	1·85	5·6	37·2	5·94	2·5	41·5	2·96	5·3	38·7	1·22	10·7	26·8
13	1·01	7·1	35·9	0·56	5·8	39·5	5·47	3·7	44·6	2·01	5·3	38·9	1·11	7·9	29·3
14	2·14	12·2	36·9	2·36	10·5	34·3	10·33	2·7	42·8	2·70	7·9	36·9	1·20	8·3	27·6

*This sample mislaid. Data estimated from other trails.

REVIEW

A Priority Scheme for Dutch Land Consolidation Projects: International Institute for Land Reclamation and Improvement, No. 6. H. Veenman and Zonen N.V. Wageningen, The Netherlands, 1960. 84 pp. (16 figs.) Price $1.50.

This survey indicates the methods which may be adopted in order to equip agriculture so as to make the greatest contribution to the Dutch national welfare. It is an attempt "to determine the order of priority within a given homogenous group of investments, i.e. land consolidation projects".

The survey is valid only for the Netherlands and it could not be adopted by others without considerable modification. Nevertheless, it is a guide to clear thinking on the subject of agricultural priority schemes. It is recommended to anyone concerned with rural development.

STILL–AIR INCUBATION OF HEN'S EGGS AT HIGH ALTITUDES

By D. L. Brown (Formerly Lecturer in Animal Husbandry, Egerton Agricultural College, Njoro) (Now Matopos Research Station, Bulawayo)

(Received for publication on 18th January, 1961)

Incubation of hen's eggs, using still-air incubators, at an altitude of 6,000 ft. and over, usually results in low hatchability. This is recognized by commercial poultry farmers in Kenya.

The following observations were made at an altitude of just over 7,200 ft. on Tatton Farm (Egerton Agricultural College) using two 100-120 egg-capacity Hearson Incubators heated by kerosene.

OBSERVATIONS

Pre-incubation Treatment of Eggs

Eggs collected over a period of three days and then placed in the incubator gave the best results. Up to five days gave satisfactory results but storage of eggs over five days gave exceedingly poor results. All eggs were collected from first- and second-year layers only, and one to two year old cockerels were used throughout.

A concrete-walled cabinet was used for storage purposes and this was contained in a thatched-roofed stone building. The eggs were turned daily. Not only were the temperatures kept below 60° F. (± 10° fluctuation) but by placing shallow water containers in the cabinet the relative humidity was kept up above 50 per cent even during dry periods.

The storage length is one of the most important single factors contributing towards successful incubation or otherwise at high altitudes.

Temperatures

The incubator temperatures which gave the most satisfactory results were:—

First week	102° F.
Second week . . .	102–103° F.
Third week	103–104° F.
During hatching . . .	105° F.

Lower temperatures than those shown above gave poorer results.

Relative Humidity

Incubation was carried out during both the wet and dry seasons and during both these seasons humidity was found to be of great importance. Even during the wet season, periods of low humidity were experienced which appeared to affect hatchability. To overcome the effects of these dry periods, water was poured onto the stone floor twice daily and a spray-pump containing warm water was used to spray the eggs in the incubator trays. This spraying was done after the eggs had been turned and the trays were then placed back in the incubator immediately afterwards. It is essential to ensure that the evaporation pans and sacking are kept in proper working condition, since the spray is only to supplement the water vapour given off by these pans.

Hatchability

Although, compared with low altitude incubation, the results were not, on the average, as good, the percentage of fertile eggs (candled at 14 days) which hatched ranged from 45 to 75 per cent.

SUMMARY

Factors affecting hatchability of eggs at altitudes over 7,000 ft. are mentioned. Storage length of eggs prior to incubation was found to be critical and eggs collected up to three days gave best results. Recommended temperatures are: first week, 102° F.; second week, 102-103° F.; third week, 103-104° F. and during hatching approximately 105° F. Relative humidity, especially during the dry periods, needed special care and both by watering the floor twice daily and by using a fine spray (warm water) on the eggs, also twice daily, satisfactory results were obtained. Hatchability varied between 45-75 per cent of fertile eggs candled at 14 days.

SMALL SCALE INCUBATION IN UGANDA

By J. C. M. Trail, Livestock Experimental Station, Entebbe, Uganda

(Received for publication on 20th January, 1961)

The development of the poultry industry in Uganda has led many African farmers to consider whether it is more desirable or economic to hatch their own replacement stock or purchase day-old chicks from a reputable source.

While arguments can be put forward that African farmers will always be better off buying replacements for their laying flocks from a large scale poultry farm where up-to-date methods of breeding and selection can be used, the aim of this paper is to examine the incubation results obtainable in Uganda, and the costs of production of day-old chicks by small-scale African poultry farmers.

The first factor in assessing the cost of production of day-old chicks is the value to be placed on hatching eggs. Trail (1960) showed that the cost of production of hatching eggs by an African poultry farmer in Uganda was Sh. 3/95 per dozen. This figure was arrived at for a small-scale unit producing hatching eggs all the year round—if hatching eggs were produced for only a short period each year, the cost would be slightly higher.

The following table gives the incubation records at the Livestock Experimental Station, Entebbe, from 1956 to 1960.

Year	No. of eggs set	No. infertile	Incubation loss	No. hatched	% Infertile	% Incubation loss	% Hatched
1960 (9 mths.)	33,517	6,828	6,619	20,070	20·4	24·8	59·6
1959	53,543	8,350	9,911	35,282	15·6	21·9	65·9
1958	28,818	4,846	5,299	18,673	16·8	22·1	64·8
1957	14,301	2,624	2,551	9,126	18·4	21·9	63·8
1956	3,062	368	837	1,857	12·0	31·1	60·6
Total	133,241	23,016	25,217	85,008	17·3	22·9	63·8

From these figures relating to over 133,000 eggs hatched in Uganda, it is seen that the incubation results to be expected are as follows:—

Fertility	83%
Hatchability of fertile eggs	77%
Hatchability of all eggs set	63%–64%

The costings per hatch for an African farmer hatching eggs in a small paraffin natural draught incubator (120-egg size) are as follows:—

	Sh.
Cost of 120 eggs @ Sh. 3/95 per dozen	39/50
Depreciation on incubator (10-year life)	8/00
Cost of maintenance	1/00
Fuel (6 gallons paraffin) ..	21/75
Labour and cleaning materials	15/00
	85/25

These figures are based on the incubator being used continuously, a total of 15 hatches per year being achieved. The cost of the incubator is Sh. 1,200, with a ten-year life the depreciation is Sh. 120 per year, or Sh. 8 per hatch. The maintenance of the incubator is estimated at Sh. 15 per year, covering breakage of parts such as thermometers.

The labour is estimated at one hour per day, involving the turning of the eggs by hand, four times daily, the candling of the eggs, and washing and disinfection of the incubator after each hatch, costing Sh. 15 per hatch.

At 63 per cent hatchability of all eggs set, and allowing a culling of 2 per cent at hatching, the cost of production of 74 day-old chicks is Sh. 85/25, or Sh. 1/15 per bird. This compares with the selling price of Sh. 1/66 for birds from a Government experimental farm.

These figures reflect the best possible results an African farmer is likely to achieve when he has acquired experience of incubation, and in many cases hatchability will be much lower.

For a typical African farmer wtih a laying flock of 100 hens, who requires to produce a total of 250 day-old chicks for his replacements each year, the cost of production of each day-old chick will be higher, as the annual depreciation and maintenance costs have to be shared over four hatches instead of 15, and the cost of production of the hatching eggs will be slightly increased. Under these circumstances the depreciation costs of the incubator will be raised to Sh. 30 and the maintenance costs to Sh. 3/75 per hatch, while the value of the hatching eggs will rise to Sh. 4/20 per dozen. Thus the cost of production of each hatch of 74 chicks is Sh. 112/50, or Sh. 1/52 per bird.

This price is virtually the same as charged by the Government stations, which also offer the advantages of top quality stock produced by modern breeding methods, and supported periodically, if necessary, by importations from the best available stock overseas.

Under small-scale conditions of poultry farming it would therefore appear advantageous for the African farmer always to purchase his replacement stock from a reputable farm which by reason of specialization in day-old chick production can produce superior stock at virtually the same cost as the farmer himself, rather than tie up capital in hatching equipment.

SUMMARY

The incubation results obtainable in Uganda and the costs of production by African farmers were examined. The average fertility of eggs for hatching was 83 per cent, the hatchability of fertile eggs 77 per cent and the hatchability of all eggs set 63 per cent to 64 per cent.

The cost of producticon of day-old chicks by an experienced African farmer hatching all the year round was Sh. 1/15 per chick, the cost of hatching a small number of replacements each year was Sh. 1/52 per chick. Generally speaking it is advantageous for a small-scale African farmer to purchase his replacement stock from a reputable large-scale poultry breeding establishment.

ACKNOWLEDGMENT

The author wishes to thank the Director of Veterinary Services and Animal Industry, Uganda, for permission to publish this article.

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CHANGED NOMENCLATURE OF THE AFRICAN COFFEE BERRY MOTH

By I. W. B. Nye, Commonwealth Institute of Entomology

(*Received for publication on 24th March, 1961*)

The African coffee berry moth has hitherto been recorded as *Thliptoceras octoguttalis* (Felder and Rogenhofer), [Lepidoptera, Pyralidae, Pyraustinae]. This species was originally described in the genus *Botys* Latreille from a single male specimen from Amboina Island in the Molucca Archipelago.

Mr. R. G. Tapley has kindly sent me 35 moths bred from coffee berries in an insectary at the Coffee Research Station, Lyamungu, Tanganyika. I have compared these specimens with the male holotype of *octoguttalis,* and the female holotype of *smaragdina* Butler originally described in the genus *Pyralis* Linnaeus from a single moth from Natal, South Africa. This examination, particularly of the male and female genitalia, has shown that the African coffee berry moth is conspecific with *smaragdina* and not with *octoguttalis.* Both these species are, however, similar and belong to the same genus.

In 1896 Warren proposed the genus *Prophantis* to contain the two species *octoguttalis* Felder and Rogenhofer, and *castoralis* Walker. Later in the same year, Hampson transferred *octoguttalis* to the genus *Thliptoceras* Warren (1890) and accordingly cited *Prophantis* as a junior synonym. The type species of *Thliptoceras* Warren is *T. variabilis* Warren (designated by Klima, 1939; 322), and the type species of *Prophantis* Warren is *Botys octoguttalis* Felder and Rogenhofer (designated by Klima, 1939; 351). These two type species are not congeneric, hence the genus *Prophantis* is now reinstated, *genus restitutum,* together with its type species *Prophantis octoguttalis, combinatio restituta.*

As the African coffee berry moth *smaragdina* is congeneric with *octoguttalis,* it should therefore be referred to as *Prophantis smaragdina* (Butler), *combinatio nova.* This species is widely distributed in the Ethiopian Region as is shown by the collection in the British Museum (Natural History) which contains specimens from Kenya, Tanganyika, Mozambique, Madagascar, South Africa, Congo, Sao Thomé I., Principe I., Annobon I., Ghana and Sierra Leone.

A photograph of *Prophantis smaragdina* and line drawings of the male and female genitalia are included in a revision of the world species of the genus *Prophantis* Warren which is in preparation.

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REVIEW

FRUIT, 1959. Price 10*s.* MEAT, 1959. Price 7*s.* 6*d.* DAIRY PRODUCE, 1959. Price 7*s.* 6*d.* INDUSTRIAL FIBRES, 1960. Price 10*s.* Commonwealth Economic Committee, Her Majesty's Stationery Office, England.

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